N71-23158

NASA TECHNICAL MEMORANDUM

NASA TM X-64584

CASE FILE COPY

LRV OPERATIONAL BEHAVIOR STUDY

By Fritz Kramer
Astronautics Laboratory

February 12, 1971

NASA

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

MSFC - Form 3190 (September 1968)

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. TM X-64584	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE LRV Operational Behavior Study		5. REPORT DATE February 12, 1971
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR (S) Fritz Kramer		8. PERFORMING ORGANIZATION REPORT #
9. PERFORMING ORGANIZATION NAME AND ADDRESS George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812		10. WORK UNIT NO.
		11. CONTRACT OR GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D.C. 20546		13. TYPE OF REPORT & PERIOD COVERED Technical Memorandum
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Prepared by Astronautics Laboratory, Science and Engineering

16. ABSTRACT

Operational behavior of the LRV under lunar gravitation has been studied using a four-wheel mathematical model with three degrees of freedom. Motion was determined on smooth, horizontal, and sloping planes under the influence of the individual wheel forces and the grade component of the gravitational force. Because of the low value of lunar gravitation, all motion is characterized by its creation through acceleration forces, which are small in comparison to mass or inertia forces.

17. KEY WORDS	18. DISTRIBUTION STATEMENT Unclassified-Unlimited Fritz Kramer

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	61	$3.00

MSFC - Form 3292 (May 1969)

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF TABLES (Concluded)

TECHNICAL MEMORANDUM X- 64584

LRV OPERATIONAL BEHAVIOR STUDY

SUMMARY

Operational behavior of the LRV under lunar gravitation has been studied using a four-wheel mathematical model with three degrees of freedom. Motion was determined on smooth, horizontal, and sloping planes under the influence of the individual wheel forces and the grade component of the gravitational force. Because of the low value of lunar gravitation, all motion is characterized by its creation through acceleration forces, which are small in comparison to mass or inertia forces.

INTRODUCTION

In these studies, the wheel-soil interaction forces were computed for each one of the four wheels of the LRV, according to the individual wheel speed and the general operating conditions to be studied. The components of these forces in the longitudinal and lateral direction of the vehicle yield the translatory accelerations, while the moment of these forces about the vertical axis through the vehicle's center of mass yields the rotational acceleration. The motion of the vehicle within a moon-fixed coordinate system is then obtained by step-wise integration; motion on an inclined or sloping plane can be determined by introducing two slope angles in the x- and y-direction of the moon-fixed coordinate system.

No bumps, surface irregularities, or sprung wheel systems have been considered.

The study could not be based on detailed, precise numerical values of the various forces acting on the wheels, since experimental data covering all operational conditions are not available. This lack of data is also noticeable in the area of systems data such as the free traction forces of the drive system in its powered and unpowered operations, the effect of temperature extremes on drive system efficiency, and others.

An attempt has been made to obtain the needed data by analysis, incorporating data from tests on some of the mechanical systems, as well as wheel-soil interaction test data available in literature.

For the above reasons, the study should not be considered to be a performance analysis; its results are intended to indicate typical response or behavior patterns of the LRV when subjected to the operational conditions as they may prevail on the moon.

FORCES ACTING ON THE WHEEL

General

The forces acting on the LRV wheel under general operating conditions are depicted in Figure 1. They are:

A radial wheel load (acting in the plane of the wheel and perpendicular to the plane supporting the wheel)

T traction force, thrust (providing positive acceleration in the forward direction of the vehicle; no driving in reverse considered)

B braking force (creating a negative acceleration opposite to the direction of motion)

S side force, cornering force (acting perpendicular to the plane of the wheel, direction and magnitude depending on the yaw angle that the wheel plane makes with the instantaneous velocity vector of the wheel)

Since vehicle motion in this study takes place on a smooth, plane surface, no vertical acceleration occurs. If the surface is also horizontal, the sum of the four radial wheel loads must be equal to the weight of the vehicle at all times, the individual wheel load depending on the location of the wheel relative to the vehicle's center of mass. However, when the vehicle is in motion, it accelerates, decelerates, makes turns, and moves on horizontal as well as on sloping ground. This causes the load distribution between the four wheels to change continuously, which, in turn, causes the reaction forces B, T, and S to change also; they change proportionally to the wheel load A . Therefore, each powered wheel will contribute to the vehicle thrust according to its loading. This assumption is compatible with a multiple wheel drive control, where each drive operates independently of the other. Since the remaining reaction forces B and S are also proportional to the wheel loading A , the wheel forces may be expressed as

$$T = \mu_T \cdot A \quad ,$$

$$B = \mu_B \cdot A \quad ,$$

$$S = k_s \cdot A \quad ,$$

where μ and k_s are dimensionless force coefficients.

The individual μ- and k_s-values should reflect their dependency upon wheel velocity and yaw angle, respectively, as well as any other effect that may be known to exist.

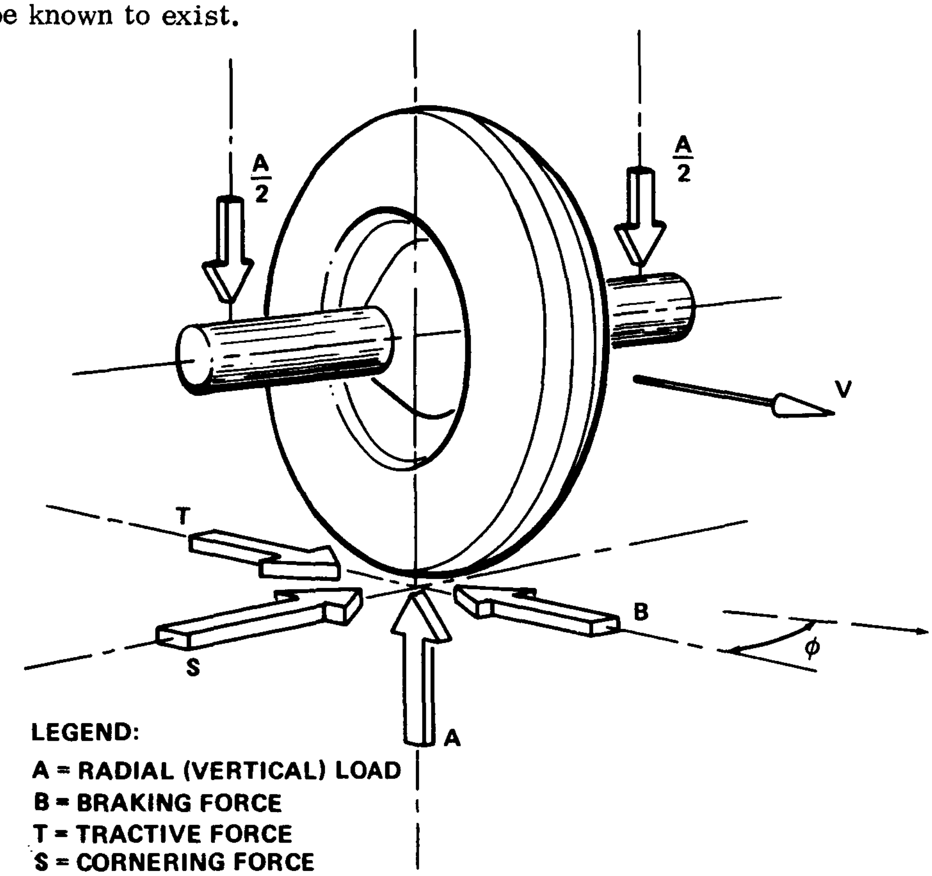


Figure 1. Basic wheel forces

Magnitude of Force Coefficients

The force coefficients used in this study could not be based on actual tests pertaining to the LRV but had to be construed from information in the literature.

The traction force coefficient, representing the free force available at the circumference of the wheel as a function of electric power input and wheel (or vehicle) speed, has not yet been determined experimentally. For this study, it had to be derived analytically from general mechanical laws as discussed in the appendix. The coefficients obtained as a function of wheel speed for various power levels are shown in Figure 2.

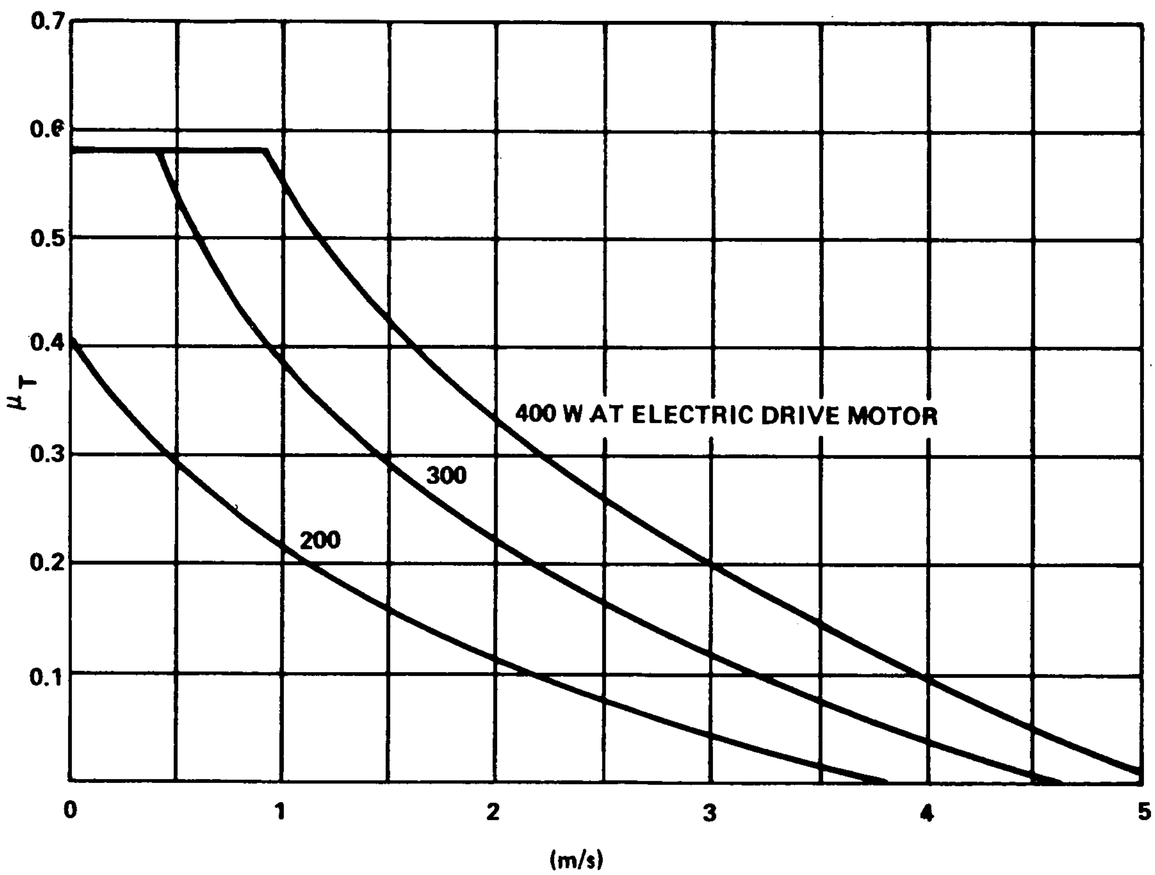


Figure 2. Tractive force coefficients.

The braking force coefficient μ_B is shown in Figure 3. It was assumed to be constant in the speed range from 0 to 10.5 km/hr at a value of 0.525.

This assumption is equivalent to optimum brake application resulting in shortest braking distance and time; in actuality, these optimum values may not be attainable, and actual braking distances will be greater. Above a velocity of 10.5 km/hr the braking coefficient is shown to tend toward a lower value, because at the higher wheel speed, the wheel's slippage tends to change to pure slip with reduced braking efficiency. This is a general tendency of wheels on hard surfaces, which may not be entirely correct for wheels in loose or lunar soil. However, from an operational point of view, it may represent a more realistic brake application at the higher speed at which the possibility of locking the wheel because of reduced wheel-soil interaction should be avoided.

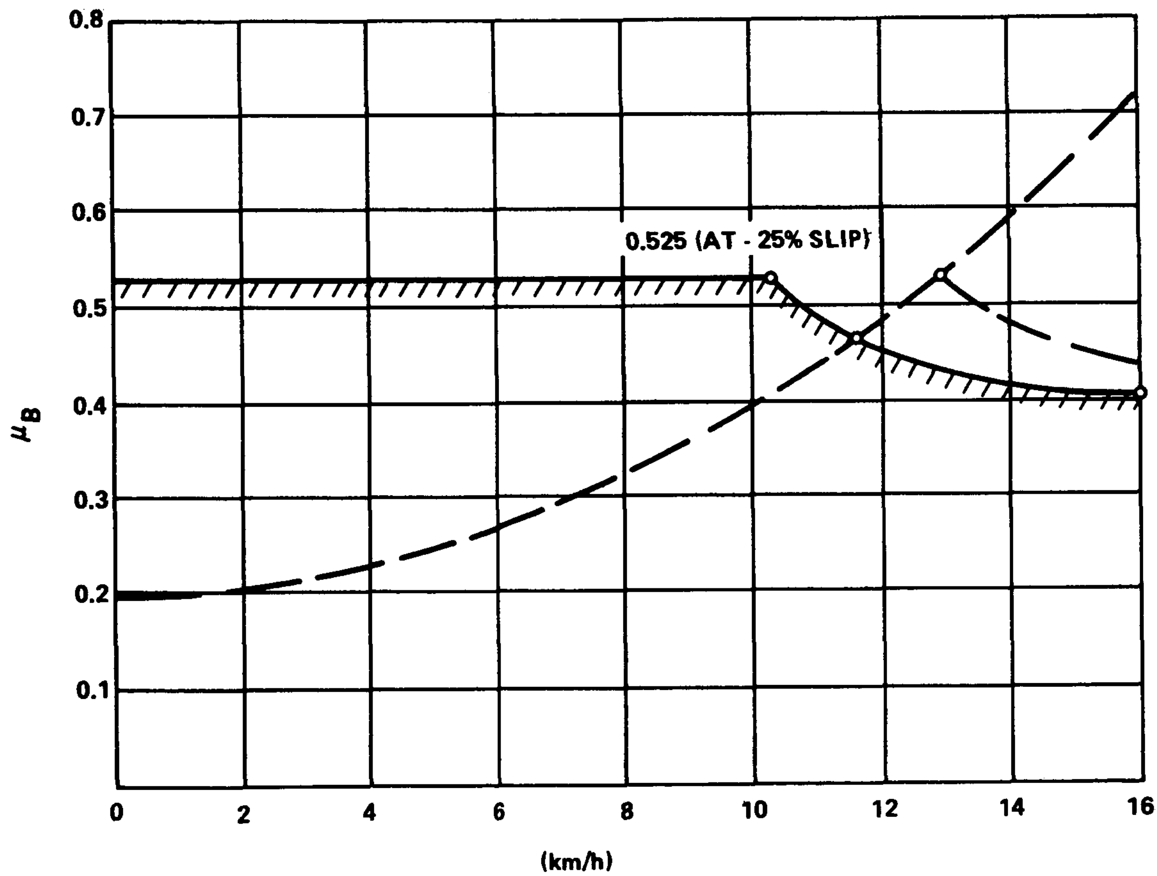


Figure 3. Braking force coefficient.

Cornering forces produced by the LRV wheel under a yaw angle in lunar soil are not presently known. However, tests performed by H. Schwanghart[1] and G. Krick[2] with rubber-tired wheels in loose soil showed results which appear to be applicable to the LRV.

While cornering force tests with wheels on hard surfaces show a force coefficient leveling off at higher yaw angles (to approximately $k_s = 0.6$ at 35 deg yaw), the force tests in loose soil show no such limit but continue to increase in magnitude. Figure 4 shows the values used in this study.

Cornering force tests with the LRV wheel in simulated lunar soil are presently under preparation at Waterways Experiment Station, Vicksburg, Mississippi. Test results may become available by mid-March 1971.

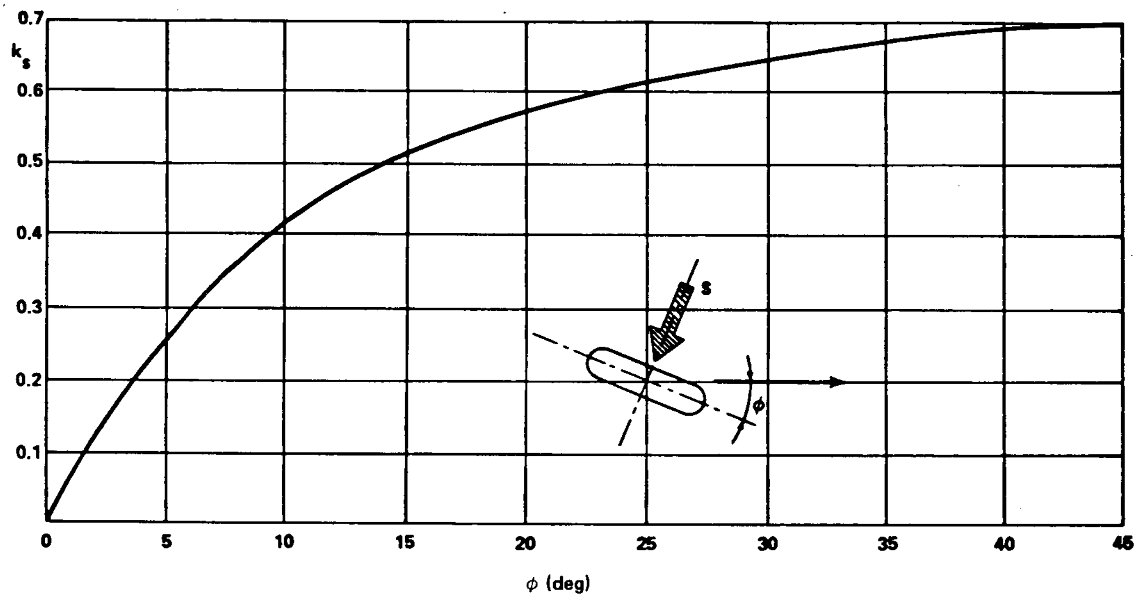


Figure 4. Cornering force coefficient.

1. H. Schwanghart: Lateral Forces on Steered Tyres in Loose Soil. Journal of Terramechanics, Vol. 5, No. 1, Institute for Agricultural Machinery, TH Munchen, Pergamon Press Ltd, Great Britain, 1968.

2. G. Krick: Systems for Measuring Forces and Moments in Power-Driven, Yawing Wheels, the Pressure Distribution and Stresses in the Plane of Contact, as well as the Tire Deformations. Working Conference of the 3rd Section of C.I.G.R. at Wageningen, The Netherlands, October 19-23, 1970, Nederlandse Vereniging Technieck in de Landbouw (in German).

Straight-Ahead Motion Without Steering

Using the traction coefficients shown in Figure 1 for the three power levels of 200, 300, and 400 W, the vehicle was started from rest ($v = 0.10$ m/s) on horizontal and inclined planes with slopes of 20, 10, -10, and -20 deg. The results are presented in Figures 5 through 7 showing the time and distance required to attain speeds of 4, 8, 12, and 16 km/hr, a speed of 16 km/hr being attainable only on downslopes of greater than 5 deg.

The effect of optimum braking is presented in Figure 8, showing the time and distance required to bring the vehicle to a complete stop from an initial speed of 16, 12, 8, and 4 km/hr, respectively. On a horizontal plane, for instance, with an initial speed of 12 km/hr, it would require a distance of 6.9 m (23 ft) to bring the LRV to a stop within 3.9 s. However, on a 20-deg downslope, it would require 24.6 m and 14.1 s.

Figure 9 has been included to identify the symbols appearing in Tables 1 through 9, which are computer printouts of some of the cases shown in Figures 5 through 8. Tables 3 through 9, representing the motion of the LRV on side-sloping terrain up to 20 deg, may be of particular interest; these are not shown in the figures. The tables give the magnitude of the side forces (cornering forces) exerted by the ground on the wheel caused by the side slope; they also give an indication of the initial oscillation of the LRV (about its vertical axis) at the beginning of the drive on a side-sloping terrain.

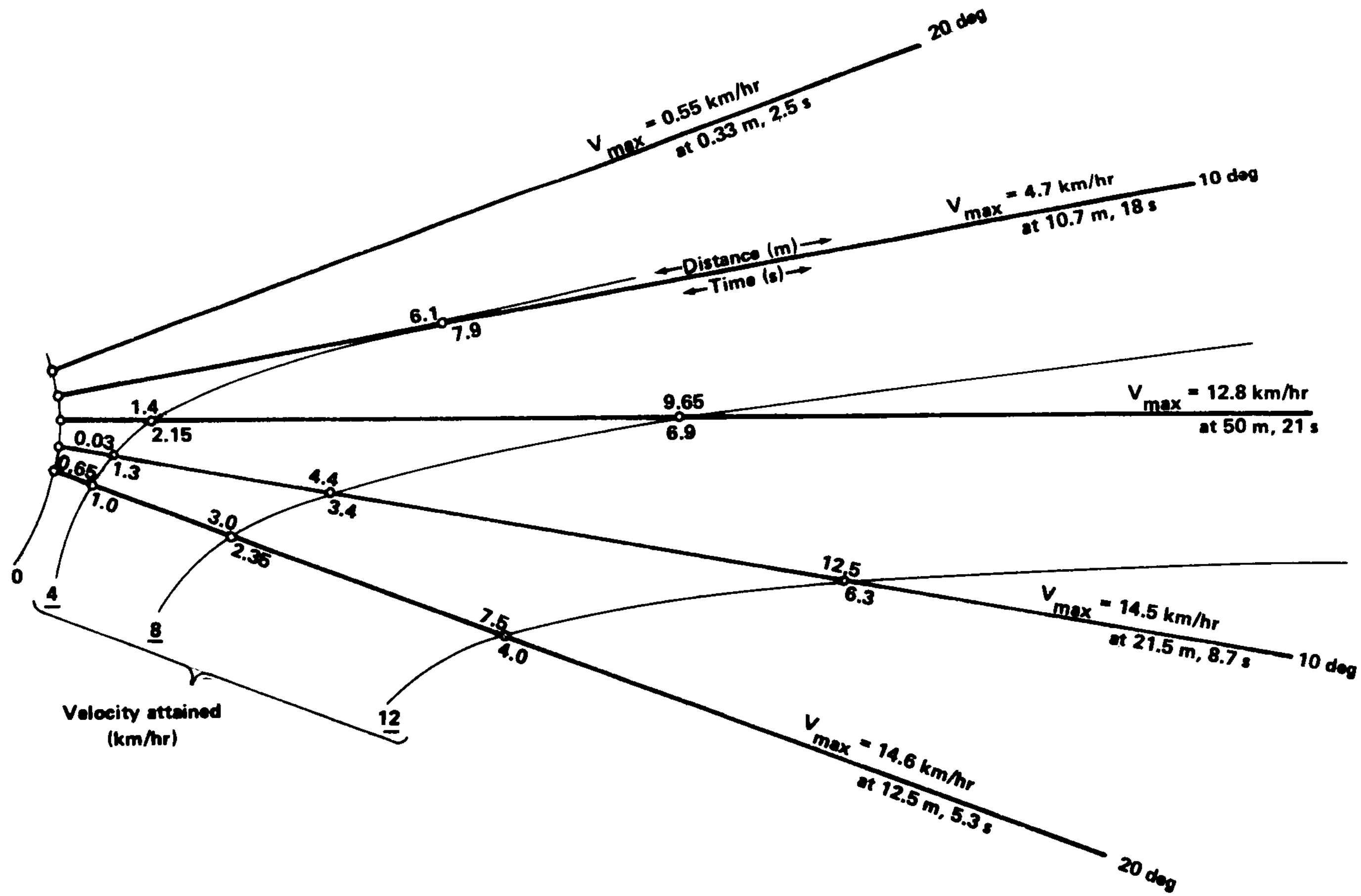


Figure 5. Driving at 200 W, typical performance.

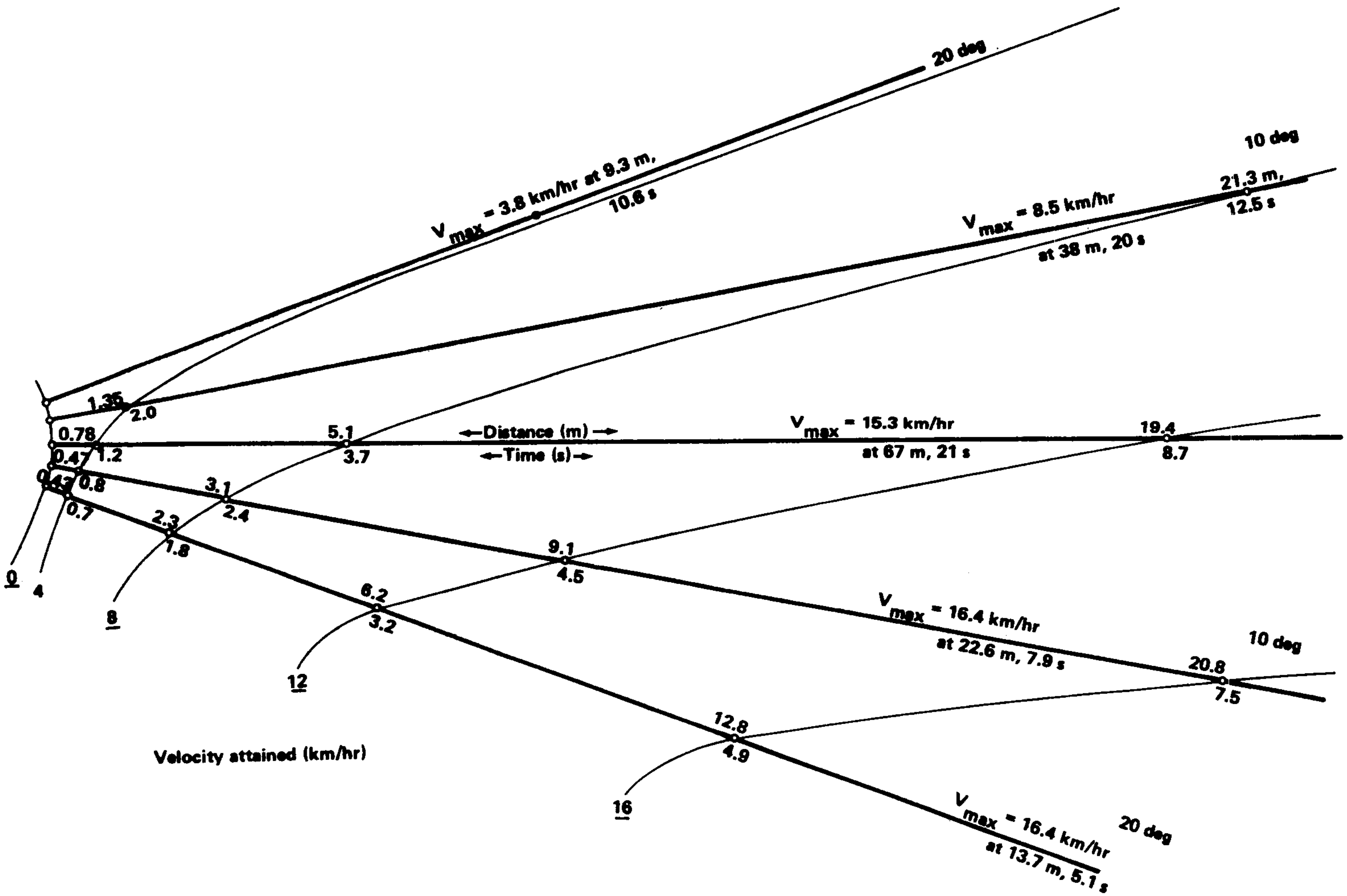


Figure 6. Driving at 300 W, typical performance.

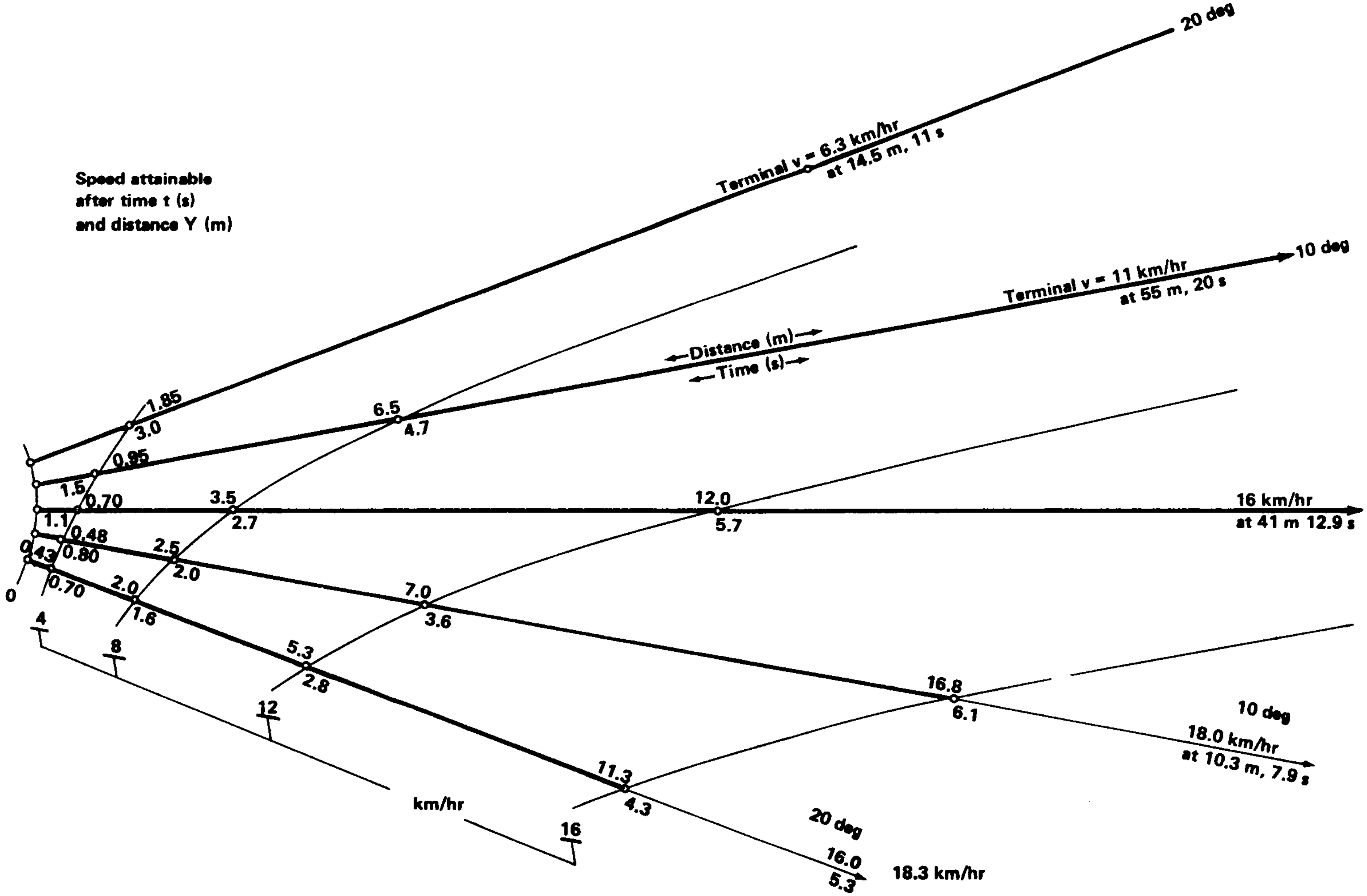


Figure 7. Driving at 400 W, typical performance.

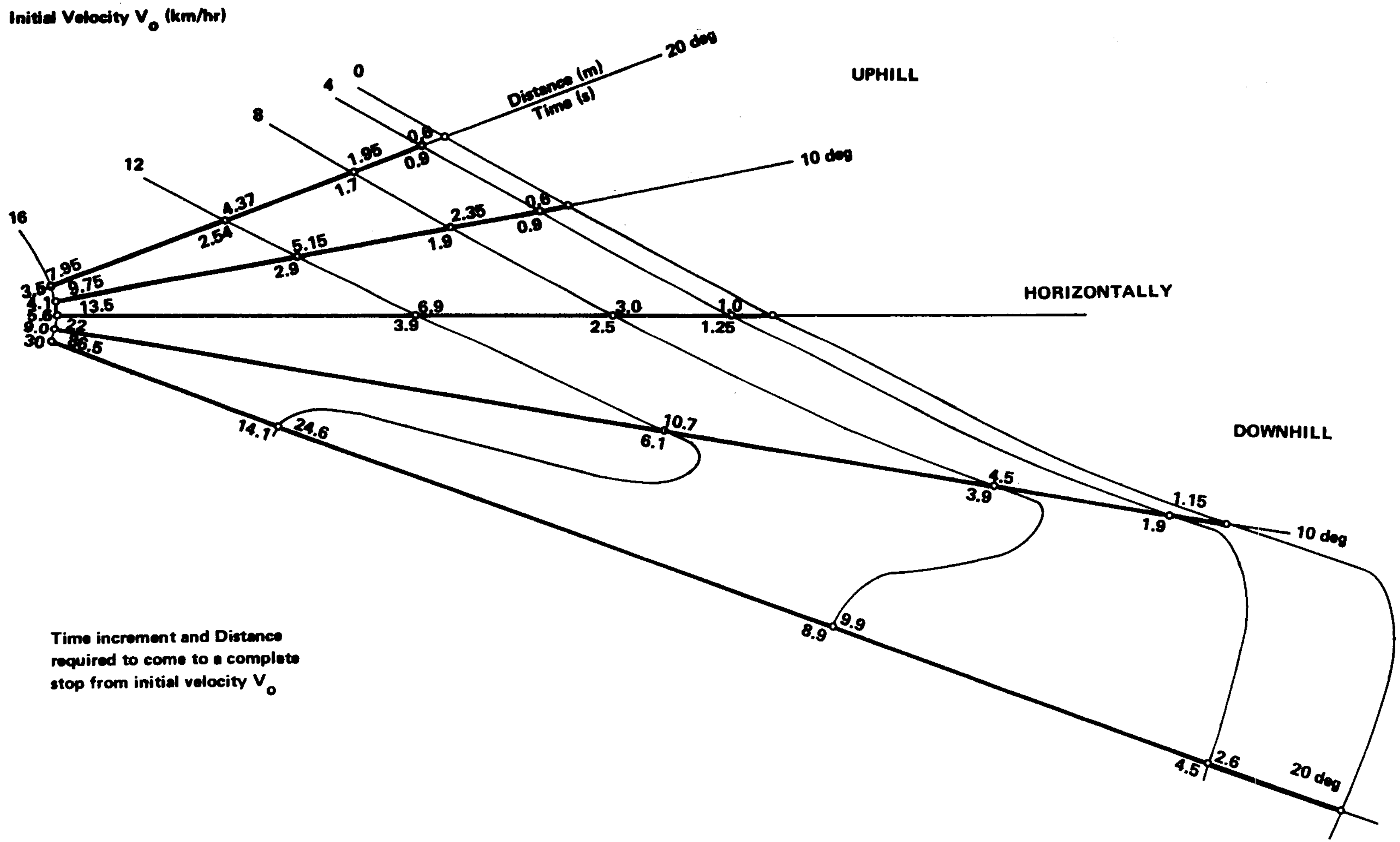
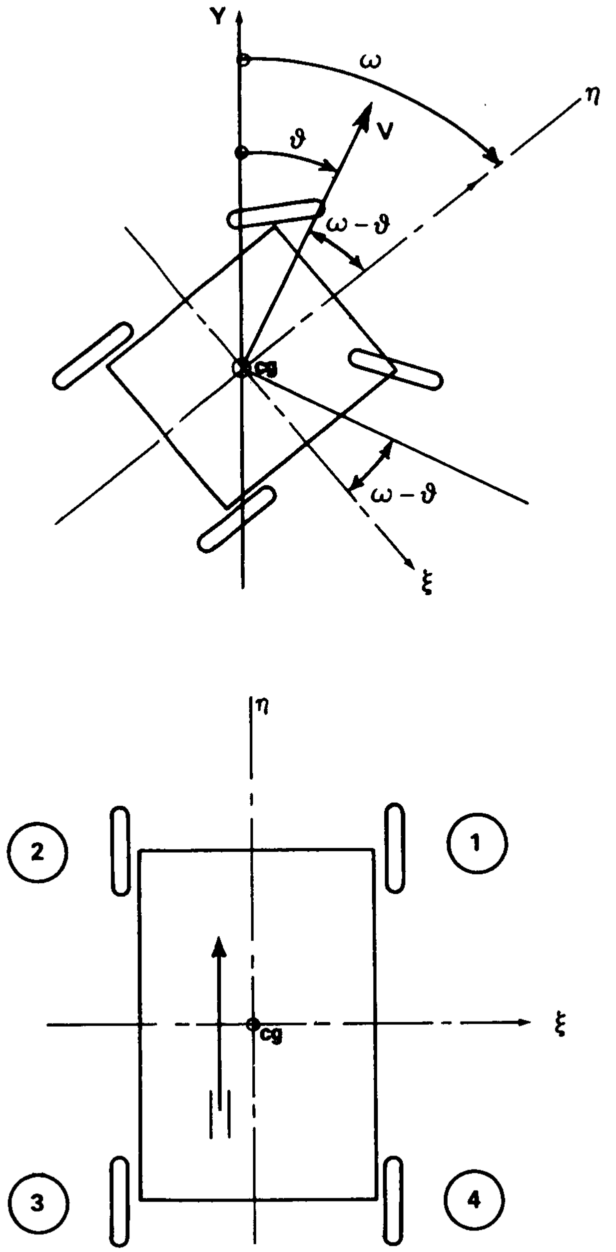


Figure 8. Braking, typical performance.



COURSE ANGLE ϑ
VEHICLE ORIENTATION ω
WITHIN MOON-FIXED
(x-,y-,) COORDINATE SYSTEM

WHEEL IDENTIFICATION
FOR
WHEEL LOADS A_n, B_n, AND S_n

WHEEL IDENTIFICATION (n)
(NEUTRAL WHEEL POSITION)

Figure 9. Identification of symbols.

TABLE 1. DRIVING STRAIGHT AHEAD ON 10 DEG UPHILL SLOPE AT 200 W

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	0.10	0.00	0.00	0.00	0.00	23.50	23.50	31.00	31.00	8.93	8.93	11.78	11.78	0.00	0.00	0.00	0.00
0.1	0.13	0.01	0.00	0.00	0.00	18.74	18.74	34.93	34.93	6.97	6.97	13.00	13.00	0.00	0.00	0.00	0.00
0.3	0.20	0.04	0.00	0.00	0.00	18.97	18.97	34.70	34.70	6.77	6.77	12.38	12.38	0.00	0.00	0.00	0.00
0.5	0.26	0.09	0.00	0.00	0.00	19.22	19.22	34.45	34.45	6.58	6.58	11.81	11.81	0.00	0.00	0.00	0.00
0.7	0.32	0.15	0.00	0.00	0.00	19.45	19.45	34.22	34.22	6.41	6.41	11.28	11.28	0.00	0.00	0.00	0.00
0.9	0.37	0.22	0.00	-0.00	0.00	19.66	19.66	34.01	34.01	6.24	6.24	10.80	10.80	0.00	0.00	0.00	0.00
1.1	0.42	0.30	0.00	-0.00	-0.00	19.86	19.86	33.81	33.81	6.10	6.10	10.38	10.38	0.00	0.00	0.00	0.00
1.3	0.46	0.38	-0.00	-0.00	0.00	20.03	20.03	33.64	33.64	5.97	5.97	10.03	10.03	0.00	0.00	0.00	0.00
1.5	0.50	0.48	0.00	0.00	0.00	20.17	20.17	33.50	33.50	5.85	5.85	9.72	9.72	0.00	0.00	0.00	0.00
1.7	0.54	0.58	0.00	0.00	-0.00	20.31	20.31	33.36	33.36	5.77	5.77	9.48	9.48	0.00	0.00	0.00	0.00
1.9	0.57	0.69	0.00	-0.00	0.00	20.40	20.40	33.27	33.27	5.68	5.68	9.27	9.27	0.00	0.00	0.00	0.00
2.1	0.61	0.81	-0.00	-0.00	0.00	20.50	20.50	33.18	33.18	5.60	5.60	9.07	9.07	0.00	0.00	0.00	0.00
2.3	0.64	0.94	0.00	0.00	-0.00	20.58	20.58	33.09	33.09	5.52	5.52	8.88	8.88	0.00	0.00	0.00	0.00
2.5	0.67	1.07	0.00	-0.00	-0.00	20.66	20.66	33.01	33.01	5.45	5.45	8.70	8.70	0.00	0.00	0.00	0.00
2.7	0.70	1.20	0.00	-0.00	0.00	20.74	20.74	32.93	32.93	5.37	5.37	8.53	8.53	0.00	0.00	0.00	0.00
2.9	0.73	1.35	-0.00	0.00	0.00	20.81	20.81	32.86	32.86	5.30	5.30	8.37	8.37	0.00	0.00	0.00	0.00
3.1	0.75	1.49	0.00	0.00	-0.00	20.88	20.88	32.79	32.79	5.24	5.24	8.22	8.22	0.00	0.00	0.00	0.00
3.3	0.78	1.65	0.00	-0.00	-0.00	20.95	20.95	32.72	32.72	5.17	5.17	8.08	8.08	0.00	0.00	0.00	0.00
3.5	0.80	1.81	-0.00	-0.00	0.00	21.01	21.01	32.66	32.66	5.11	5.11	7.95	7.95	0.00	0.00	0.00	0.00
3.7	0.82	1.97	-0.00	0.00	0.00	21.07	21.07	32.60	32.60	5.06	5.06	7.82	7.82	0.00	0.00	0.00	0.00
3.9	0.84	2.13	0.00	0.00	-0.00	21.13	21.13	32.54	32.54	5.00	5.00	7.70	7.70	0.00	0.00	0.00	0.00
4.1	0.86	2.31	0.00	-0.00	-0.00	21.18	21.18	32.49	32.49	4.95	4.95	7.59	7.59	0.00	0.00	0.00	0.00
4.3	0.88	2.48	-0.00	-0.00	0.00	21.23	21.23	32.44	32.44	4.90	4.90	7.48	7.48	0.00	0.00	0.00	0.00
4.5	0.90	2.66	-0.00	0.00	0.00	21.28	21.28	32.39	32.39	4.85	4.85	7.38	7.38	0.00	0.00	0.00	0.00
4.7	0.92	2.84	0.00	0.00	-0.00	21.32	21.32	32.35	32.35	4.81	4.81	7.30	7.30	0.00	0.00	0.00	0.00
4.9	0.93	3.03	0.00	-0.00	-0.00	21.36	21.36	32.31	32.31	4.77	4.77	7.22	7.22	0.00	0.00	0.00	0.00
5.1	0.95	3.21	-0.00	-0.00	0.00	21.39	21.39	32.28	32.28	4.74	4.74	7.15	7.15	0.00	0.00	0.00	0.00
5.3	0.96	3.41	-0.00	0.00	0.00	21.43	21.43	32.24	32.24	4.70	4.70	7.08	7.08	0.00	0.00	0.00	0.00
5.5	0.98	3.60	0.00	0.00	-0.00	21.46	21.46	32.21	32.21	4.67	4.67	7.01	7.01	0.00	0.00	0.00	0.00
5.7	0.99	3.80	0.00	-0.00	-0.00	21.49	21.49	32.18	32.18	4.64	4.64	6.95	6.95	0.00	0.00	0.00	0.00
5.[illegible]	1.01	4.00	0.00	-0.00	0.00	21.52	21.52	32.15	32.15	4.61	4.61	6.89	6.89	0.00	0.00	0.00	0.00
6.1	1.02	4.20	-0.00	0.00	0.00	21.55	21.55	32.13	32.13	4.58	4.58	6.84	6.84	0.00	0.00	0.00	0.00
6.3	1.03	4.40	0.00	0.00	-0.00	21.57	21.57	32.10	32.10	4.56	4.56	6.78	6.78	0.00	0.00	0.00	0.00
6.5	1.04	4.61	0.00	-0.00	-0.00	21.59	21.59	32.08	32.08	4.53	4.53	6.73	6.73	0.00	0.00	0.00	0.00
6.7	1.05	4.82	0.00	-0.00	0.00	21.62	21.62	32.05	32.05	4.51	4.51	6.69	6.69	0.00	0.00	0.00	0.00
6.9	1.06	5.03	0.00	0.00	0.00	21.64	21.64	32.03	32.03	4.49	4.49	6.64	6.64	0.00	0.00	0.00	0.00
7.1	1.07	5.25	0.00	0.00	-0.00	21.66	21.66	32.01	32.01	4.46	4.46	6.60	6.60	0.00	0.00	0.00	0.00
7.3	1.08	5.46	0.00	-0.00	-0.00	21.68	21.68	31.99	31.99	4.44	4.44	6.56	6.56	0.00	0.00	0.00	0.00
7.5	1.09	5.68	0.00	-0.00	0.00	21.70	21.70	31.97	31.97	4.42	4.42	6.52	6.52	0.00	0.00	0.00	0.00
7.7	1.10	5.90	0.00	0.00	0.00	21.72	21.72	31.95	31.95	4.40	4.40	6.48	6.48	0.00	0.00	0.00	0.00
7.9	1.11	6.12	0.00	0.00	-0.00	21.73	21.73	31.94	31.94	4.38	4.38	6.44	6.44	0.00	0.00	0.00	0.00
8.1	1.12	6.34	0.00	0.00	-0.00	21.75	21.75	31.92	31.92	4.37	4.37	6.41	6.41	0.00	0.00	0.00	0.00
8.3	1.13	6.57	0.00	-0.00	0.00	21.77	21.77	31.90	31.90	4.35	4.35	6.37	6.37	0.00	0.00	0.00	0.00
8.5	1.14	6.80	0.00	-0.00	0.00	21.78	21.78	31.89	31.89	4.33	4.33	6.34	6.34	0.00	0.00	0.00	0.00
8.7	1.14	7.02	0.00	0.00	0.00	21.80	21.80	31.87	31.87	4.31	4.31	6.31	6.31	0.00	0.00	0.00	0.00
8.9	1.15	7.25	0.00	0.00	-0.00	21.81	21.81	31.86	31.86	4.30	4.30	6.28	6.28	0.00	0.00	0.00	0.00
9.9	1.18	8.42	0.00	0.00	0.00	21.88	21.88	31.79	31.79	4.23	4.23	6.14	6.14	0.00	0.00	0.00	0.00
10.1	1.19	8.65	0.00	-0.00	0.00	21.89	21.89	31.78	31.78	4.22	4.22	6.12	6.12	0.00	0.00	0.00	0.00
14.9	1.27	14.58	0.00	0.00	0.00	22.06	22.06	31.61	31.61	4.03	4.03	5.77	5.77	0.00	0.00	0.00	0.00
15.1	1.27	14.84	0.00	0.00	0.00	22.07	22.07	31.61	31.61	4.02	4.02	5.76	5.76	0.00	0.00	0.00	0.00
19.9	1.30	21.03	0.00	0.00	0.00	22.13	22.13	31.54	31.54	3.95	3.95	5.63	5.63	0.00	0.00	0.00	0.00
20.1	1.30	21.30	0.00	0.00	0.00	22.13	22.13	31.54	31.54	3.95	3.95	5.63	5.63	0.00	0.00	0.00	0.00
24.9	1.32	27.59	0.00	0.00	0.00	22.15	22.15	31.52	31.52	3.92	3.92	5.58	5.58	0.00	0.00	0.00	0.00

TABLE 2. DRIVING STRAIGHT AHEAD ON HORIZONTAL PLANE AT 400 W

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	0.10	0.00	0.00	0.00	0.00	23.50	23.50	31.00	31.00	13.72	13.72	18.10	18.10	0.00	0.00	0.00	0.00
0.1	0.20	0.01	0.00	0.00	0.00	15.74	15.74	38.75	38.75	9.19	9.19	22.63	22.63	0.00	0.00	0.00	0.00
0.3	0.39	0.07	0.00	0.00	0.00	15.74	15.74	38.75	38.75	9.19	9.19	22.63	22.63	0.00	0.00	0.00	0.00
0.5	0.58	0.17	0.00	-0.00	0.00	15.74	15.74	38.75	38.75	9.18	9.18	22.60	22.60	0.00	0.00	0.00	0.00
0.7	0.77	0.30	-0.00	-0.00	0.00	15.76	15.76	38.74	38.74	9.16	9.16	22.52	22.52	0.00	0.00	0.00	0.00
0.9	0.96	0.48	-0.00	0.00	0.00	15.79	15.79	38.71	38.71	8.82	8.82	21.63	21.63	0.00	0.00	0.00	0.00
1.1	1.15	0.69	0.00	0.00	-0.00	16.16	16.16	38.33	38.33	8.20	8.20	19.45	19.45	0.00	0.00	0.00	0.00
1.3	1.32	0.94	0.00	0.00	0.00	17.01	17.01	37.49	37.49	7.88	7.88	17.36	17.36	0.00	0.00	0.00	0.00
1.5	1.48	1.22	0.00	-0.00	0.00	17.75	17.75	36.75	36.75	7.50	7.50	15.53	15.53	0.00	0.00	0.00	0.00
1.7	1.63	1.53	0.00	-0.00	-0.00	18.42	18.42	36.08	36.08	7.29	7.29	14.28	14.28	0.00	0.00	0.00	0.00
1.9	1.76	1.87	0.00	0.00	-0.00	18.87	18.87	35.63	35.63	7.02	7.02	13.26	13.26	0.00	0.00	0.00	0.00
2.1	1.89	2.23	0.00	-0.00	0.00	19.26	19.26	35.24	35.24	6.74	6.74	12.33	12.33	0.00	0.00	0.00	0.00
2.3	2.01	2.62	0.00	0.00	0.00	19.63	19.63	34.87	34.87	6.46	6.46	11.48	11.48	0.00	0.00	0.00	0.00
2.5	2.12	3.03	0.00	0.00	0.00	19.97	19.97	34.53	34.53	6.25	6.25	10.81	10.81	0.00	0.00	0.00	0.00
2.7	2.22	3.47	0.00	0.00	0.00	20.24	20.24	34.26	34.26	6.02	6.02	10.20	10.20	0.00	0.00	0.00	0.00
2.9	2.32	3.92	0.00	0.00	0.00	20.50	20.50	34.00	34.00	5.80	5.80	9.62	9.62	0.00	0.00	0.00	0.00
3.1	2.42	4.39	0.00	0.00	0.00	20.74	20.74	33.76	33.76	5.58	5.58	9.09	9.09	0.00	0.00	0.00	0.00
3.3	2.51	4.89	0.00	0.00	0.00	20.97	20.97	33.53	33.53	5.37	5.37	8.58	8.58	0.00	0.00	0.00	0.00
3.5	2.59	5.40	0.00	0.00	0.00	21.19	21.19	33.31	33.31	5.18	5.18	8.15	8.15	0.00	0.00	0.00	0.00
3.7	2.66	5.92	0.00	0.00	0.00	21.37	21.37	33.12	33.12	5.00	5.00	7.75	7.75	0.00	0.00	0.00	0.00
3.9	2.75	6.47	0.00	0.00	0.00	21.55	21.55	32.95	32.95	4.82	4.82	7.36	7.36	0.00	0.00	0.00	0.00
4.1	2.83	7.02	0.00	0.00	0.00	21.73	21.73	32.77	32.77	4.64	4.64	7.00	7.00	0.00	0.00	0.00	0.00
4.3	2.90	7.60	0.00	0.00	0.00	21.89	21.89	32.61	32.61	4.47	4.47	6.66	6.66	0.00	0.00	0.00	0.00
4.5	2.97	8.18	0.00	0.00	0.00	22.05	22.05	32.45	32.45	4.30	4.30	6.33	6.33	0.00	0.00	0.00	0.00
4.7	3.03	8.78	0.00	0.00	0.00	22.20	22.20	32.30	32.30	4.15	4.15	6.04	6.04	0.00	0.00	0.00	0.00
4.9	3.10	9.40	0.00	0.00	0.00	22.33	22.33	32.17	32.17	4.02	4.02	5.79	5.79	0.00	0.00	0.00	0.00
5.1	3.16	10.02	0.00	0.00	0.00	22.45	22.45	32.05	32.05	3.89	3.89	5.55	5.55	0.00	0.00	0.00	0.00
5.3	3.22	10.66	0.00	0.00	0.00	22.56	22.56	31.94	31.94	3.76	3.76	5.32	5.32	0.00	0.00	0.00	0.00
5.5	3.27	11.31	0.00	0.00	0.00	22.67	22.67	31.83	31.83	3.63	3.63	5.10	5.10	0.00	0.00	0.00	0.00
5.7	3.32	11.97	0.00	0.00	0.00	22.78	22.78	31.72	31.72	3.51	3.51	4.89	4.89	0.00	0.00	0.00	0.00
5.9	3.38	12.64	0.00	0.00	0.00	22.88	22.88	31.62	31.62	3.39	3.39	4.68	4.68	0.00	0.00	0.00	0.00
6.1	3.43	13.32	0.00	0.00	0.00	22.98	22.98	31.52	31.52	3.27	3.27	4.49	4.49	0.00	0.00	0.00	0.00
6.3	3.47	14.01	0.00	0.00	0.00	23.07	23.07	31.43	31.43	3.16	3.16	4.31	4.31	0.00	0.00	0.00	0.00
6.5	3.52	14.71	0.00	0.00	0.00	23.16	23.16	31.34	31.34	3.06	3.06	4.14	4.14	0.00	0.00	0.00	0.00
6.7	3.56	15.42	0.00	0.00	0.00	23.24	23.24	31.26	31.26	2.98	2.98	4.00	4.00	0.00	0.00	0.00	0.00
6.9	3.61	16.13	0.00	0.00	0.00	23.31	23.31	31.19	31.19	2.89	2.89	3.87	3.87	0.00	0.00	0.00	0.00
7.1	3.65	16.86	0.00	0.00	0.00	23.37	23.37	31.12	31.12	2.81	2.81	3.74	3.74	0.00	0.00	0.00	0.00
7.3	3.69	17.59	0.00	0.00	0.00	23.44	23.44	31.06	31.06	2.73	2.73	3.62	3.62	0.00	0.00	0.00	0.00
7.5	3.73	18.33	0.00	0.00	0.00	23.50	23.50	31.00	31.00	2.65	2.65	3.50	3.50	0.00	0.00	0.00	0.00
7.7	3.76	19.08	0.00	0.00	0.00	23.56	23.56	30.94	30.94	2.57	2.57	3.38	3.38	0.00	0.00	0.00	0.00
7.9	3.80	19.84	0.00	0.00	0.00	23.62	23.62	30.88	30.88	2.50	2.50	3.27	3.27	0.00	0.00	0.00	0.00
8.1	3.83	20.60	0.00	0.00	0.00	23.68	23.68	30.82	30.82	2.43	2.43	3.16	3.16	0.00	0.00	0.00	0.00
8.3	3.87	21.37	0.00	0.00	0.00	23.73	23.73	30.77	30.77	2.36	2.36	3.06	3.06	0.00	0.00	0.00	0.00
8.5	3.90	22.15	0.00	0.00	0.00	23.79	23.79	30.71	30.71	2.29	2.29	2.95	2.95	0.00	0.00	0.00	0.00
8.7	3.93	22.93	0.00	0.00	0.00	23.84	23.84	30.66	30.66	2.22	2.22	2.86	2.86	0.00	0.00	0.00	0.00
8.9	3.97	23.72	0.00	0.00	0.00	23.89	23.89	30.61	30.61	2.16	2.16	2.76	2.76	0.00	0.00	0.00	0.00
9.9	4.11	27.76	0.00	0.00	0.00	24.09	24.09	30.41	30.41	1.91	1.91	2.41	2.41	0.00	0.00	0.00	0.00
10.1	4.13	28.58	0.00	0.00	0.00	24.12	24.12	30.38	30.38	1.87	1.87	2.35	2.35	0.00	0.00	0.00	0.00
14.9	4.60	49.67	0.00	0.00	0.00	24.74	24.74	29.76	29.76	1.00	1.00	1.20	1.20	0.00	0.00	0.00	0.00
15.1	4.62	50.59	0.00	0.00	0.00	24.76	24.76	29.74	29.74	0.97	0.97	1.16	1.16	0.00	0.00	0.00	0.00
19.9	4.83	73.34	0.00	0.00	0.00	25.14	25.14	29.36	29.36	0.43	0.43	0.50	0.50	0.00	0.00	0.00	0.00
20.1	4.84	74.31	0.00	0.00	0.00	25.15	25.15	29.35	29.35	0.41	0.41	0.48	0.48	0.00	0.00	0.00	0.00
24.9	4.93	97.79	0.00	0.00	0.00	25.31	25.31	29.19	29.19	0.18	0.18	0.21	0.21	0.00	0.00	0.00	0.00

TABLE 3. DRIVING STRAIGHT AHEAD ON DOUBLE SLOPE, 20 DEG DOWN, 10 DEG SIDE, AT 400 W

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	0.10	0.00	0.00	0.00	0.00	23.50	23.50	31.00	31.00	13.72	13.72	18.10	18.10	0.00	0.00	0.00	0.00
0.1	0.25	0.02	0.00	15.35	0.00	13.89	13.89	36.63	36.63	8.11	8.11	21.39	21.39	7.42	7.42	19.57	19.57
0.3	0.53	0.09	0.02	10.03	0.24	24.18	5.01	24.97	46.89	14.12	2.92	14.57	27.38	13.27	2.59	5.92	12.55
0.5	0.79	0.22	0.01	-16.00	0.74	20.70	8.50	28.96	42.89	12.04	4.94	16.82	24.96	10.44	4.06	16.98	26.17
0.7	1.03	0.40	-0.03	-10.50	0.62	4.40	24.87	47.59	24.19	2.31	13.98	26.75	12.73	2.30	13.71	16.76	7.79
0.9	1.26	0.62	-0.04	6.60	-0.42	7.89	22.29	43.67	27.20	3.60	11.33	22.19	12.40	0.33	1.11	21.96	12.51
1.1	1.50	0.90	0.00	10.91	-1.02	22.42	9.67	27.19	41.77	9.58	4.10	11.52	17.85	10.77	4.62	12.59	12.46
1.3	1.74	1.22	0.05	6.41	-0.37	25.45	8.60	23.87	43.13	10.07	3.11	8.63	17.06	11.80	3.72	3.86	7.64
1.5	1.96	1.58	0.08	2.96	0.69	22.46	12.86	27.38	38.35	7.87	4.20	8.94	13.44	5.91	3.19	0.24	0.37
1.7	2.17	2.00	0.10	2.34	1.17	19.84	16.83	30.47	33.91	6.06	5.11	9.25	10.36	1.69	1.42	1.82	2.04
1.9	2.38	2.45	0.12	2.95	1.03	20.13	17.66	30.22	33.05	5.44	4.91	8.40	8.92	1.26	1.13	4.66	5.01
2.1	2.58	2.95	0.15	3.40	0.74	21.51	17.23	28.71	33.60	5.24	4.29	7.14	8.19	2.69	2.18	5.04	5.83
2.3	2.78	3.48	0.18	3.47	0.60	22.59	17.00	27.53	33.92	4.99	3.77	6.10	7.49	3.55	2.68	4.52	5.56
2.5	2.96	4.06	0.22	3.37	0.61	23.08	17.28	27.03	33.66	4.56	3.39	5.31	6.65	3.73	2.78	4.09	5.10
2.7	3.13	4.66	0.25	3.28	0.67	23.33	17.76	26.79	33.17	4.13	3.12	4.71	5.87	3.62	2.75	3.87	4.80
2.9	3.30	5.31	0.29	3.24	0.72	23.54	18.20	26.61	32.71	3.71	2.85	4.17	5.15	3.51	2.71	3.78	4.65
3.1	3.46	5.98	0.33	3.25	0.76	23.76	18.56	26.39	32.34	3.30	2.57	3.65	4.49	3.48	2.71	3.75	4.59
3.3	3.62	6.69	0.37	3.27	0.79	24.03	18.86	26.13	32.03	2.96	2.32	3.21	3.95	3.50	2.75	3.72	4.57
3.5	3.77	7.43	0.41	3.30	0.81	24.26	19.10	25.89	31.79	2.66	2.08	2.82	3.47	3.54	2.78	3.71	4.55
3.7	3.92	8.19	0.45	3.33	0.82	24.49	19.31	25.66	31.58	2.33	1.84	2.44	3.01	3.58	2.82	3.69	4.54
3.9	4.06	8.99	0.50	3.36	0.84	24.71	19.52	25.44	31.38	2.05	1.62	2.11	2.61	3.62	2.86	3.67	4.53
4.1	4.20	9.81	0.55	3.39	0.86	24.91	19.69	25.24	31.20	1.82	1.44	1.84	2.28	3.66	2.89	3.65	4.52
4.3	4.33	10.67	0.60	3.41	0.88	25.07	19.84	25.08	31.06	1.59	1.25	1.59	1.97	3.69	2.92	3.64	4.51
4.5	4.47	11.54	0.65	3.43	0.89	25.22	19.98	24.92	30.91	1.36	1.07	1.34	1.67	3.72	2.94	3.63	4.50
4.7	4.60	12.46	0.71	3.46	0.91	25.38	20.12	24.77	30.78	1.06	0.84	1.03	1.29	3.75	2.97	3.61	4.49
4.9	4.72	13.38	0.76	3.48	0.92	25.57	20.30	24.58	30.60	0.74	0.58	0.71	0.89	3.78	3.00	3.59	4.48
5.1	4.84	14.33	0.82	3.50	0.94	25.77	20.49	24.37	30.41	0.43	0.33	0.40	0.50	3.82	3.04	3.57	4.46
5.3	4.96	15.31	0.88	3.52	0.95	25.97	20.68	24.18	30.22	0.12	0.09	0.10	0.19	3.86	3.07	3.55	4.44
5.5	5.08	16.31	0.94	3.54	0.97	26.16	20.86	23.99	30.04	0.00	0.00	0.00	0.00	3.89	3.10	3.52	4.41

TABLE 4. DRIVING STRAIGHT AHEAD ON DOUBLE SLOPE, 10 DEG DOWN, 10 DEG SIDE, AT 400 W

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	0.10	0.00	0.00	0.00	0.00	23.50	23.50	31.00	31.00	13.72	13.72	18.10	18.10	0.00	0.00	0.00	0.00
0.1	0.22	0.02	0.00	16.07	0.00	14.99	14.99	37.89	37.89	8.75	8.75	22.13	22.13	8.17	8.17	20.65	20.65
0.3	0.45	0.08	0.02	9.14	0.24	25.51	5.04	25.90	49.30	14.90	2.94	15.13	28.79	14.17	2.60	4.10	9.01
0.5	0.66	0.19	0.00	-18.41	0.68	20.58	9.97	31.54	43.67	12.00	5.81	18.37	25.46	11.36	5.29	19.18	27.37
0.7	0.66	0.34	-0.03	-9.54	0.32	4.07	26.52	50.41	24.75	2.32	15.42	29.31	14.11	2.20	15.53	9.58	3.98
0.9	1.04	0.52	-0.03	10.20	-0.84	9.81	20.93	43.86	31.16	5.06	12.01	25.18	16.07	1.80	4.51	25.64	16.83
1.1	1.26	0.75	0.02	12.86	-1.22	24.46	7.14	27.18	46.98	12.28	3.44	13.11	23.68	13.63	3.87	12.66	22.68
1.3	1.44	1.01	0.06	5.75	-0.22	26.08	7.32	25.45	46.91	12.15	2.99	10.40	21.85	13.07	3.34	0.47	1.03
1.5	1.63	1.32	0.08	1.93	0.91	20.65	14.29	31.78	39.05	8.37	5.50	12.23	15.83	4.29	2.80	2.61	3.45
1.7	1.82	1.66	0.09	2.42	1.06	18.48	18.11	34.38	34.79	6.57	6.66	12.64	12.36	0.14	0.14	5.31	5.21
1.9	2.00	2.04	0.11	3.60	0.52	20.68	17.04	31.94	36.10	6.68	5.76	10.84	11.67	1.42	1.23	7.95	8.62
2.1	2.17	2.46	0.14	3.76	0.14	22.77	15.94	29.62	37.43	6.94	4.91	9.12	11.41	4.05	2.86	6.21	7.79
2.3	2.32	2.91	0.17	3.38	0.17	23.46	16.04	28.88	37.38	6.70	4.51	8.12	10.67	4.68	3.16	4.52	5.91
2.5	2.47	3.39	0.19	3.07	0.35	23.36	16.87	29.06	36.48	6.15	4.37	7.53	9.61	4.09	2.93	3.96	5.01
2.7	2.62	3.89	0.22	2.99	0.48	23.31	17.63	29.17	35.66	5.66	4.25	7.04	8.66	3.57	2.69	4.03	4.94
2.9	2.75	4.43	0.25	3.05	0.52	23.49	18.08	29.01	35.19	5.26	4.05	6.49	7.88	3.44	2.65	4.21	5.11
3.1	2.88	4.99	0.28	3.13	0.52	23.81	18.34	28.68	34.94	4.92	3.79	6.93	7.22	3.54	2.73	4.31	5.24
3.3	3.01	5.58	0.31	3.19	0.52	24.16	18.54	28.32	34.74	4.60	3.53	5.39	6.61	3.69	2.83	4.31	5.29
3.5	3.13	6.19	0.35	3.23	0.62	24.48	18.76	28.00	34.54	4.33	3.31	4.94	6.10	3.79	2.90	4.28	5.28
3.7	3.24	6.83	0.38	3.26	0.54	24.72	18.95	27.75	34.35	4.05	3.10	4.53	5.62	3.85	2.95	4.25	5.26
3.9	3.36	7.49	0.42	3.28	0.66	24.94	19.15	27.52	34.15	3.77	2.89	4.15	5.16	3.90	2.99	4.22	5.24
4.1	3.46	8.17	0.46	3.31	0.67	25.18	19.34	27.31	33.96	3.49	2.68	3.79	4.72	3.93	3.02	4.20	5.22
4.3	3.57	8.87	0.50	3.33	0.59	25.35	19.53	27.11	33.76	3.28	2.50	3.47	4.33	3.97	3.06	4.18	5.21
4.5	3.66	9.59	0.54	3.35	0.60	25.53	19.70	26.93	33.60	3.04	2.34	3.20	4.00	4.00	3.09	4.17	5.20
4.7	3.76	10.34	0.59	3.38	0.62	25.69	19.84	26.78	33.46	2.83	2.18	2.94	3.68	4.04	3.12	4.16	5.20
4.9	3.85	11.10	0.63	3.40	0.63	25.84	19.98	26.62	33.32	2.62	2.02	2.69	3.37	4.07	3.14	4.14	5.19
5.1	3.94	11.87	0.68	3.42	0.64	25.99	20.11	26.47	33.19	2.41	1.86	2.45	3.08	4.10	3.17	4.13	5.18
5.3	4.03	12.67	0.73	3.44	0.66	26.13	20.24	26.33	33.06	2.22	1.72	2.24	2.81	4.13	3.20	4.12	5.18
5.5	4.12	13.48	0.77	3.46	0.67	26.26	20.35	26.20	32.95	2.07	1.61	2.07	2.60	4.16	3.22	4.11	5.17
5.7	4.20	14.31	0.83	3.48	0.68	26.37	20.45	26.09	32.86	1.93	1.49	1.90	2.40	4.18	3.24	4.10	5.17
5.9	4.28	15.16	0.88	3.50	0.69	26.47	20.54	25.99	32.77	1.78	1.38	1.74	2.20	4.21	3.26	4.10	5.17
6.1	4.36	16.02	0.93	3.51	0.70	26.57	20.62	25.89	32.68	1.63	1.27	1.59	2.01	4.23	3.28	4.09	5.17
6.3	4.44	16.90	0.98	3.53	0.71	26.67	20.71	25.79	32.60	1.49	1.16	1.44	1.82	4.25	3.30	4.09	5.17
6.5	4.51	17.79	1.04	3.55	0.72	26.76	20.79	25.69	32.51	1.35	1.04	1.29	1.63	4.28	3.32	4.08	5.16
6.7	4.59	18.70	1.10	3.56	0.73	26.86	20.88	25.59	32.43	1.15	0.89	1.09	1.39	4.30	3.34	4.07	5.16
6.9	4.66	19.63	1.15	3.57	0.74	26.99	20.99	25.47	32.31	0.96	0.74	0.90	1.15	4.33	3.36	4.06	5.15
7.1	4.73	20.56	1.21	3.59	0.74	27.11	21.11	25.34	32.20	0.77	0.60	0.72	0.91	4.35	3.39	4.04	5.14
7.3	4.80	21.51	1.27	3.60	0.75	27.23	21.22	25.22	32.09	0.59	0.45	0.54	0.69	4.38	3.41	4.03	5.13
7.5	4.86	22.48	1.33	3.62	0.76	27.34	21.32	25.11	31.99	0.41	0.32	0.37	0.48	4.40	3.43	4.01	5.11
7.7	4.92	23.45	1.39	3.63	0.78	27.45	21.43	25.00	31.89	0.24	0.18	0.21	0.27	4.42	3.45	4.00	5.10
7.9	4.98	24.44	1.46	3.65	0.79	27.56	21.52	24.89	31.79	0.07	0.05	0.06	0.08	4.45	3.47	3.99	5.09
8.1	5.04	25.44	1.52	3.66	0.80	27.66	21.62	24.79	31.69	0.00	0.00	0.00	0.00	4.47	3.49	3.98	5.09

TABLE 5. DRIVING STRAIGHT AHEAD ON HORIZONTAL PLANE WITH 10 DEG SIDE SLOPE AT 400 W

0.0	0.10	0.00	0.00	0.00	0.00	23.50	23.50	31.00	31.00	13.72	13.72	18.10	18.10	0.00	0.00	0.00	0.00
0.1	0.20	0.01	0.00	16.31	0.00	15.36	15.36	38.31	38.31	8.97	8.97	22.37	22.37	8.43	8.43	21.02	21.02
0.3	0.37	0.07	0.01	7.98	0.25	25.96	5.05	26.21	50.12	15.16	2.95	15.31	29.27	14.70	2.61	0.74	1.76
0.5	0.53	0.16	0.00	-18.86	0.56	19.03	11.99	34.14	42.19	11.11	7.00	19.94	24.64	11.00	6.83	20.47	25.66
0.7	0.67	0.27	-0.02	-5.01	-0.11	4.15	26.87	51.15	25.18	2.41	15.68	29.84	14.63	2.20	16.33	18.70	7.09
0.9	0.81	0.42	-0.01	13.21	-1.15	16.81	14.24	36.67	39.62	9.76	8.28	21.33	23.00	6.68	6.13	21.66	22.30
1.1	0.98	0.60	0.03	9.86	-0.72	25.64	5.47	26.59	49.64	14.88	2.87	13.93	28.82	15.85	3.09	3.47	7.86
1.3	1.14	0.81	0.05	2.40	0.70	21.21	10.46	31.69	43.98	11.37	5.04	15.26	23.57	8.77	3.85	6.95	11.23
1.5	1.31	1.05	0.06	2.17	1.19	15.65	17.63	38.16	35.90	7.17	8.33	18.03	16.45	0.63	0.74	5.46	4.97
1.7	1.47	1.33	0.07	4.48	0.50	19.05	15.83	34.39	38.07	7.79	7.06	15.34	15.56	0.28	0.26	12.67	12.93
1.9	1.62	1.64	0.10	4.52	-0.09	22.53	13.63	30.50	40.67	8.92	5.46	12.21	16.10	4.75	2.91	7.98	10.51
2.1	1.76	1.97	0.12	3.42	0.06	23.19	13.91	29.81	40.43	8.84	5.12	10.97	16.41	5.96	3.45	3.46	4.90
2.3	1.87	2.34	0.14	2.79	0.46	22.06	15.75	31.16	38.37	7.88	5.46	10.84	13.71	4.15	2.89	2.58	3.27
2.5	1.99	2.72	0.16	2.94	0.62	21.57	16.99	31.78	37.01	7.15	5.64	10.55	12.27	2.90	2.28	4.39	5.10
2.7	2.10	3.13	0.18	3.26	0.54	22.23	17.02	31.07	37.02	6.97	5.39	9.84	11.61	3.01	2.32	5.33	6.29
2.9	2.21	3.56	0.21	3.40	0.44	22.91	16.89	30.33	37.21	6.85	5.08	9.12	11.13	3.59	2.66	5.25	6.41
3.1	2.31	4.01	0.23	3.39	0.41	23.33	16.97	29.89	37.16	6.66	4.84	8.52	10.61	3.92	2.85	4.90	6.10
3.3	2.40	4.48	0.26	3.35	0.44	23.54	17.23	29.68	36.90	6.40	4.67	8.04	10.04	3.95	2.88	4.69	5.85
3.5	2.49	4.97	0.29	3.33	0.48	23.70	17.52	29.53	36.59	6.13	4.52	7.62	9.47	3.88	2.87	4.64	5.76
3.7	2.58	5.48	0.32	3.35	0.50	23.87	17.78	29.36	36.33	5.90	4.39	7.24	8.97	3.86	2.87	4.65	5.76
3.9	2.66	6.00	0.35	3.38	0.52	24.06	17.97	29.18	36.14	5.68	4.24	6.88	6.53	3.89	2.90	4.67	5.78
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
6.1	3.37	12.68	0.76	3.59	0.62	25.66	19.36	27.56	34.77	3.84	2.90	4.13	5.21	4.27	3.22	4.55	5.75
6.3	3.42	13.36	0.80	3.61	0.63	25.76	19.44	27.46	34.68	3.71	2.80	3.95	5.00	4.30	3.24	4.55	5.74
6.5	3.46	14.04	0.85	3.62	0.63	25.86	19.53	27.36	34.60	3.59	2.70	3.79	4.80	4.32	3.26	4.54	5.74
6.7	3.51	14.74	0.89	3.64	0.64	25.96	19.61	27.26	34.51	3.46	2.62	3.64	4.61	4.34	3.28	4.53	5.74
6.9	3.56	15.44	0.93	3.65	0.65	26.04	19.69	27.17	34.44	3.37	2.54	3.51	4.45	4.37	3.30	4.53	5.74
7.1	3.60	16.16	0.98	3.66	0.65	26.12	19.75	27.10	34.37	3.27	2.47	3.39	4.30	4.38	3.31	4.52	5.74
7.3	3.64	16.88	1.03	3.67	0.66	26.19	19.81	27.02	34.31	3.18	2.40	3.28	4.16	4.40	3.33	4.52	5.74
7.5	3.68	17.61	1.07	3.69	0.67	26.26	19.87	26.95	34.26	3.09	2.33	3.16	4.03	4.42	3.34	4.51	5.74
7.7	3.72	18.36	1.12	3.70	0.67	26.33	19.93	26.89	34.20	3.00	2.27	3.06	3.89	4.44	3.36	4.51	5.74
7.9	3.76	19.10	1.17	3.71	0.68	26.39	19.98	26.82	34.15	2.91	2.20	2.95	3.76	4.45	3.37	4.51	5.74
8.1	3.80	19.86	1.22	3.72	0.68	26.46	20.04	26.76	34.09	2.82	2.14	2.85	3.64	4.47	3.38	4.60	5.74
8.3	3.83	20.61	1.27	3.73	0.69	26.52	20.09	26.70	34.04	2.74	2.08	2.76	3.52	4.49	3.40	4.50	5.74
8.5	3.87	21.38	1.32	3.74	0.69	26.58	20.14	26.64	33.99	2.66	2.02	2.67	3.40	4.50	3.41	4.49	5.74
8.7	3.90	22.15	1.37	3.75	0.70	26.63	20.19	26.58	33.94	2.58	1.96	2.58	3.29	4.52	3.42	4.49	5.73
8.9	3.93	22.94	1.42	3.75	0.70	26.69	20.24	26.52	33.90	2.51	1.90	2.49	3.18	4.53	3.43	4.49	5.73
9.1	3.96	23.72	1.47	3.76	0.71	26.74	20.28	26.47	33.85	2.43	1.84	2.41	3.08	4.54	3.45	4.48	5.73
9.3	3.99	24.52	1.52	3.77	0.71	26.79	20.33	26.42	33.81	2.36	1.79	2.33	2.98	4.56	3.46	4.48	5.73
9.5	4.02	25.32	1.58	3.78	0.71	26.84	20.37	26.36	33.76	2.30	1.75	2.26	2.89	4.57	3.47	4.47	5.73
9.7	4.05	26.12	1.63	3.79	0.72	26.89	20.41	26.32	33.73	2.25	1.71	2.20	2.82	4.58	3.48	4.47	5.73
9.9	4.08	26.94	1.68	3.80	0.72	26.92	20.44	26.28	33.70	2.20	1.67	2.14	2.75	4.59	3.48	4.47	5.73
10.1	4.11	27.75	1.74	3.80	0.73	26.96	20.47	26.25	33.67	2.15	1.63	2.09	2.68	4.60	3.49	4.47	5.73
10.3	4.14	28.57	1.79	3.81	0.73	26.99	20.50	26.21	33.64	2.10	1.59	2.04	2.61	4.61	3.50	4.47	5.73
10.5	4.16	29.40	1.85	3.82	0.73	27.03	20.52	26.18	33.61	2.05	1.56	1.98	2.55	4.62	3.51	4.47	5.73
10.7	4.19	30.24	1.90	3.82	0.73	27.06	20.55	26.14	33.58	2.00	1.52	1.93	2.49	4.63	3.52	4.46	5.73
10.9	4.21	31.07	1.96	3.83	0.74	27.10	20.58	26.11	33.56	1.96	1.49	1.88	2.42	4.64	3.52	4.46	5.74
11.1	4.24	31.92	2.02	3.83	0.74	27.13	20.61	26.08	33.53	1.91	1.45	1.84	2.36	4.65	3.53	4.46	5.74
11.3	4.26	32.74	2.07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
29.9	5.00	******	8.25	4.01	0.81	28.39	21.67	24.80	32.48	0.03	0.02	0.02	0.03	5.00	3.82	4.37	5.72
30.1	5.00	******	8.32	4.01	0.81	28.39	21.67	24.80	32.48	0.02	0.02	0.02	0.03	5.00	3.82	4.37	5.72

TABLE 6. DRIVING STRAIGHT AHEAD ON DOUBLE SLOPE, 10 DEG UP, 10 DEG SIDE, AT 400 W

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	0.10	0.00	0.00	0.00	0.00	23.50	23.50	31.00	31.00	13.72	13.72	18.10	18.10	0.00	0.00	0.00	0.00
0.1	0.17	0.01	0.00	16.07	0.00	14.99	14.99	37.89	37.89	8.75	8.75	22.13	22.13	8.17	8.17	20.65	20.65
0.3	0.28	0.06	0.01	6.75	0.24	25.51	5.04	25.90	49.30	14.90	2.94	15.13	28.79	15.01	2.65	3.70	8.81
0.5	0.39	0.12	0.00	-16.00	0.39	16.19	14.36	36.56	38.65	9.46	8.39	21.35	22.57	9.41	8.60	18.96	19.22
0.7	0.49	0.21	-0.00	5.01	-0.62	5.30	25.26	49.01	26.20	3.09	14.75	28.62	15.26	2.60	15.80	33.55	15.30
0.9	0.58	0.31	0.02	20.56	-1.65	20.69	9.88	31.42	43.78	12.07	5.77	18.34	25.54	12.12	5.94	20.28	27.69
1.1	0.68	0.44	0.05	8.82	-0.75	27.01	3.56	24.19	51.00	15.77	2.07	14.05	29.78	18.62	2.19	6.56	19.93
1.3	0.78	0.58	0.07	2.03	0.67	14.28	16.30	38.74	36.44	8.31	9.46	22.49	21.20	5.20	5.28	7.52	8.05
1.5	0.92	0.75	0.08	6.67	0.34	14.42	16.23	38.59	36.52	7.77	9.43	22.42	19.69	2.28	3.14	21.16	17.91
1.7	1.04	0.94	0.10	7.38	-0.82	21.63	9.67	30.40	44.06	11.23	5.42	17.03	22.88	3.31	1.66	15.43	20.81
1.9	1.15	1.16	0.12	3.25	-0.98	23.39	8.75	28.45	45.17	12.16	4.34	14.10	23.49	8.31	2.92	2.40	4.14
2.1	1.25	1.40	0.13	0.78	-0.38	19.60	13.29	32.83	40.04	9.66	6.23	15.39	19.73	4.30	2.74	2.60	3.42
2.3	1.35	1.66	0.14	1.78	-0.24	17.09	16.73	35.76	36.17	7.67	7.72	16.50	16.23	0.62	0.63	6.50	6.38
2.5	1.45	1.94	0.15	3.16	-0.66	19.86	14.84	32.66	38.40	8.37	6.56	14.44	16.19	1.96	1.55	9.46	10.61
2.7	1.53	2.24	0.16	2.96	-0.90	21.93	13.55	30.35	39.93	9.06	5.59	12.52	16.50	4.62	2.85	6.12	8.07
2.9	1.61	2.55	0.18	2.27	-0.74	21.87	14.18	30.46	39.25	8.82	5.61	12.04	15.83	4.80	3.04	3.74	4.93
3.1	1.68	2.88	0.19	2.03	-0.53	21.17	15.31	31.29	37.99	8.22	5.89	12.03	14.76	3.61	2.58	3.96	4.86
3.3	1.75	3.23	0.20	2.19	-0.49	21.12	15.79	31.38	37.47	7.89	5.92	11.77	14.00	3.03	2.28	5.02	5.98
3.5	1.81	3.58	0.22	2.38	-0.55	21.55	15.75	30.92	37.54	7.80	5.74	11.26	13.59	3.26	2.39	5.41	6.53
3.7	1.87	3.95	0.23	2.43	-0.60	21.96	15.71	30.47	37.62	7.74	5.54	10.75	13.25	3.65	2.61	5.19	6.40
3.9	1.93	4.33	0.25	2.41	-0.59	22.18	15.83	30.25	37.50	7.60	5.41	10.34	12.86	3.80	2.71	4.93	6.12
4.1	1.99	4.72	0.27	2.39	-0.56	22.28	16.05	30.15	37.28	7.43	5.33	10.02	12.43	3.77	2.71	4.85	6.01
4.3	2.04	5.12	0.28	2.40	-0.54	22.40	16.24	30.04	37.08	7.28	5.28	9.76	12.06	3.72	2.69	4.89	6.04
4.5	2.09	5.54	0.30	2.43	-0.53	22.52	16.37	29.91	36.95	7.16	5.20	9.51	11.75	3.73	2.71	4.93	6.09
4.7	2.13	5.96	0.32	2.45	-0.53	22.66	16.46	29.78	36.86	7.05	5.12	9.27	11.48	3.77	2.74	4.94	6.12
4.9	2.17	6.39	0.34	2.47	-0.53	22.79	16.55	29.65	36.78	6.95	5.05	9.04	11.22	3.81	2.77	4.93	6.12
5.1	2.22	6.83	0.36	2.48	-0.52	22.90	16.64	29.53	36.69	6.85	4.97	8.83	10.97	3.85	2.79	4.91	6.10
5.3	2.26	7.27	0.37	2.49	-0.51	23.00	16.73	29.43	36.60	6.74	4.90	8.63	10.73	3.87	2.81	4.90	6.10
5.5	2.29	7.73	0.39	2.50	-0.51	23.10	16.82	29.33	36.51	6.65	4.84	8.44	10.51	3.89	2.83	4.90	6.10
5.7	2.33	8.19	0.41	2.52	-0.50	23.19	16.90	29.24	36.43	6.55	4.77	8.26	10.29	3.91	2.85	4.89	6.10
5.9	2.36	8.66	0.44	2.53	-0.50	23.28	16.98	29.15	36.35	6.46	4.71	8.09	10.09	3.93	2.86	4.89	6.09
6.1	2.40	9.13	0.46	2.54	-0.49	23.37	17.05	29.06	36.28	6.37	4.65	7.92	9.90	3.95	2.88	4.88	6.09
6.3	2.43	9.61	0.48	2.55	-0.49	23.45	17.13	28.98	36.21	6.29	4.59	7.77	9.71	3.97	2.90	4.88	6.09
6.5	2.46	10.10	0.50	2.56	-0.48	23.53	17.19	28.90	36.14	6.21	4.54	7.62	9.54	3.99	2.91	4.87	6.09
6.7	2.48	10.60	0.52	2.57	-0.48	23.60	17.26	28.82	36.08	6.13	4.48	7.49	9.37	4.01	2.93	4.87	6.09
6.9	2.51	11.09	0.54	2.58	-0.47	23.67	17.32	28.75	36.02	6.06	4.43	7.36	9.22	4.02	2.94	4.86	6.09
7.1	2.54	11.60	0.57	2.59	-0.47	23.74	17.37	28.69	35.96	6.00	4.39	7.25	9.09	4.04	2.96	4.86	6.09
7.3	2.56	12.11	0.59	2.60	-0.47	23.80	17.42	28.63	35.91	5.94	4.35	7.14	8.96	4.05	2.97	4.85	6.09
7.5	2.58	12.62	0.61	2.61	-0.46	23.85	17.47	28.57	35.86	5.88	4.30	7.04	8.84	4.07	2.98	4.85	6.09
7.7	2.61	13.14	0.64	2.62	-0.46	23.91	17.52	28.52	35.82	5.82	4.26	6.94	8.72	4.08	2.99	4.85	6.09
7.9	2.63	13.66	0.66	2.62	-0.46	23.96	17.56	28.46	35.78	5.76	4.22	6.85	8.61	4.09	3.00	4.85	6.09
8.1	2.65	14.19	0.69	2.63	-0.45	24.01	17.60	28.41	35.74	5.71	4.19	6.76	8.50	4.11	3.01	4.84	6.09
29.9	3.12	79.87	3.85	2.77	-0.41	25.09	18.52	27.32	34.83	4.48	3.30	4.87	6.21	4.39	3.24	4.78	6.10
30.1	3.12	80.49	3.88	2.77	-0.41	25.09	18.52	27.31	34.83	4.48	3.30	4.87	6.21	4.39	3.24	4.78	6.10

TABLE 7. DRIVING STRAIGHT AHEAD ON DOUBLE SLOPE, 20 DEG UP, 10 DEG SIDE, AT 400 W

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	0.10	0.00	0.00	0.00	0.00	23.50	23.50	31.00	31.00	13.72	13.72	18.10	18.10	0.00	0.00	0.00	0.00
0.1	0.14	0.01	0.00	15.35	0.00	13.89	13.89	36.63	36.63	8.11	8.11	21.39	21.39	7.42	7.42	19.57	19.57
0.3	0.20	0.06	0.01	5.69	0.24	24.18	5.01	24.97	46.89	14.12	2.92	14.58	27.38	15.32	2.76	7.60	18.73
0.5	0.25	0.09	0.01	-8.93	0.23	13.13	16.06	37.60	34.25	7.67	9.38	21.96	20.00	7.52	10.22	4.01	2.65
0.7	0.32	0.15	0.01	12.42	-0.68	12.63	16.56	38.18	33.68	7.38	9.67	22.30	19.67	5.10	9.59	26.72	21.73
0.9	0.37	0.21	0.03	17.67	-0.92	20.59	8.60	29.07	42.78	12.03	5.02	16.98	24.98	14.42	5.63	7.69	15.56
1.1	0.42	0.29	0.04	4.54	0.54	22.32	6.47	27.09	44.76	13.04	4.01	15.80	26.14	15.63	4.33	14.68	30.89
1.3	0.47	0.38	0.05	5.84	1.57	10.05	19.15	41.12	30.73	5.87	11.18	24.01	17.94	2.09	4.00	9.76	7.24
1.5	0.54	0.48	0.07	13.49	0.84	18.70	10.50	31.24	40.61	10.89	6.13	18.24	23.66	3.13	2.52	21.28	24.91
1.7	0.60	0.59	0.09	8.20	0.09	21.81	7.41	27.69	44.14	12.71	4.32	16.14	25.73	7.57	2.60	10.67	16.85
1.9	0.66	0.71	0.10	0.74	0.61	21.31	7.92	28.26	43.56	12.42	4.61	16.44	25.40	8.73	2.82	8.73	15.81
2.1	0.72	0.85	0.10	1.56	0.85	12.31	16.92	38.54	33.27	7.16	9.85	22.43	19.35	0.82	1.18	5.32	4.43
2.3	0.79	1.00	0.11	6.86	0.26	16.00	13.26	34.32	37.47	9.29	7.71	19.97	21.74	0.87	0.88	17.87	17.68
2.5	0.85	1.17	0.13	6.10	-0.16	20.64	8.64	29.02	42.75	11.99	5.01	16.84	24.82	7.10	2.91	7.75	11.67
2.7	0.91	1.34	0.14	2.69	0.30	19.88	9.42	29.90	41.85	11.54	5.22	16.57	24.29	7.37	3.16	3.76	5.84
2.9	0.98	1.53	0.15	2.80	0.68	14.97	14.64	35.53	35.90	8.27	8.13	19.73	19.84	1.67	1.64	4.95	4.97
3.1	1.04	1.73	0.17	4.71	0.33	17.41	12.71	32.78	38.15	9.11	7.00	18.06	19.96	0.58	0.47	12.07	13.05
3.3	1.09	1.94	0.18	4.30	-0.03	19.98	10.69	29.87	40.50	10.41	5.60	15.65	21.10	4.14	2.24	7.25	9.74
3.6	1.14	2.17	0.20	2.98	0.12	19.70	11.40	30.23	39.72	10.19	5.72	15.17	20.56	5.06	2.80	1.88	2.61
3.7	1.19	2.40	0.21	2.81	0.38	17.91	13.53	32.30	37.31	8.96	6.70	16.00	18.67	3.08	2.30	3.63	4.27
3.9	1.23	2.64	0.22	3.46	0.34	18.28	13.56	31.91	37.30	8.82	6.66	15.67	18.01	2.30	1.74	6.88	7.87
4.1	1.27	2.89	0.24	3.69	0.16	19.43	12.76	30.61	38.25	9.22	6.12	14.68	18.15	3.15	2.09	6.57	8.10
4.3	1.31	3.15	0.25	3.40	0.15	19.78	12.71	30.24	38.32	9.29	5.93	14.10	17.99	3.86	2.46	4.94	6.31
4.5	1.34	3.41	0.27	3.20	0.24	19.50	13.26	30.58	37.71	9.00	6.07	13.99	17.40	3.62	2.44	4.51	5.61
4.7	1.37	3.68	0.28	3.27	0.29	19.38	13.63	30.73	37.30	8.76	6.16	13.88	16.85	3.22	2.26	5.11	6.20
4.9	1.40	3.96	0.30	3.40	0.27	19.61	13.65	30.48	37.30	8.70	6.08	13.58	16.55	3.22	2.25	5.61	6.71
5.1	1.42	4.24	0.32	3.44	0.24	19.88	13.60	30.19	37.37	8.70	5.96	13.23	16.36	3.45	2.36	5.37	6.64
5.3	1.45	4.52	0.33	3.41	0.24	20.01	13.68	30.06	37.30	8.65	5.90	12.97	16.13	3.57	2.44	5.14	6.38
5.5	1.47	4.82	0.35	3.40	0.26	20.06	13.82	30.03	37.15	8.56	5.89	12.80	15.86	3.54	2.44	5.10	6.31
5.7	1.49	5.11	0.37	3.41	0.28	20.11	13.93	29.98	37.04	8.47	5.87	12.63	15.61	3.50	2.42	5.18	6.40
5.9	1.51	5.41	0.39	3.44	0.28	20.20	13.99	29.88	36.98	8.43	5.84	12.46	15.42	3.51	2.43	5.23	6.47
6.1	1.52	5.71	0.40	3.45	0.27	20.30	14.03	29.78	36.94	8.40	5.81	12.33	15.30	3.55	2.46	5.21	6.46
6.3	1.54	6.02	0.42	3.46	0.28	20.35	14.07	29.72	36.90	8.37	5.78	12.22	15.18	3.58	2.47	5.18	6.44
:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
7.3	1.61	7.59	0.52	3.48	0.29	20.55	14.25	29.52	36.72	8.21	5.69	11.79	14.67	3.62	2.51	5.18	6.46
7.5	1.62	7.91	0.54	3.49	0.29	20.59	14.28	29.48	36.69	8.18	5.67	11.72	14.58	3.63	2.52	5.18	6.44
7.7	1.63	8.24	0.56	3.49	0.29	20.62	14.31	29.45	36.66	8.16	5.66	11.65	14.50	3.64	2.52	5.18	6.45
7.9	1.64	8.56	0.58	3.50	0.29	20.66	14.34	29.42	36.64	8.13	5.64	11.58	14.42	3.64	2.53	5.18	6.45
8.1	1.65	8.89	0.60	3.50	0.29	20.68	14.36	29.39	36.61	8.11	5.63	11.52	14.35	3.65	2.53	5.17	6.45
8.3	1.66	9.22	0.62	3.50	0.30	20.71	14.39	29.36	36.59	8.09	5.62	11.46	14.29	3.66	2.54	5.17	6.45
8.5	1.67	9.56	0.64	3.51	0.30	20.74	14.41	29.33	36.57	8.07	5.60	11.41	14.22	3.66	2.55	5.17	6.45
8.7	1.68	9.89	0.66	3.51	0.30	20.76	14.43	29.31	36.55	8.05	5.59	11.36	14.16	3.67	2.55	5.17	6.45
8.9	1.68	10.22	0.68	3.51	0.30	20.79	14.45	29.28	36.53	8.03	5.58	11.31	14.10	3.68	2.56	5.17	6.45
9.1	1.69	10.56	0.70	3.52	0.30	20.81	14.47	29.26	36.51	8.01	5.57	11.26	14.05	3.68	2.56	5.17	6.45
9.3	1.70	10.90	0.72	3.52	0.30	20.83	14.49	29.24	36.49	7.99	5.56	11.22	14.00	3.69	2.56	5.17	6.45
9.5	1.70	11.24	0.74	3.52	0.30	20.85	14.50	29.22	36.47	7.98	5.55	11.18	13.95	3.69	2.57	5.17	6.45
9.7	1.71	11.58	0.76	3.53	0.30	20.87	14.52	29.20	36.46	7.96	5.54	11.14	13.91	3.70	2.57	5.16	6.45
9.9	1.72	11.92	0.78	3.53	0.30	20.89	14.54	29.18	36.44	7.95	5.53	11.10	13.86	3.70	2.58	5.16	6.45
29.9	1.82	47.81	3.02	3.56	0.31	21.19	14.79	28.87	36.19	7.69	5.37	10.48	13.14	3.78	2.64	5.15	6.45
30.1	1.82	48.18	3.04	3.56	0.31	21.19	14.79	28.87	36.19	7.69	5.37	10.48	13.14	3.78	2.64	5.15	6.45

TABLE 8. BRAKING WHILE COASTING STRAIGHT AHEAD ON DOUBLE SLOPE, 10 DEG DOWN, 10 DEG SIDE

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	4.44	0.00	0.00	0.00	0.00	30.00	30.00	25.00	25.00	-12.00	-12.00	-10.00	-10.00	0.00	0.00	0.00	0.00
0.1	4.40	0.44	0.00	0.36	0.00	31.37	31.37	21.50	21.50	-12.56	-12.56	-8.61	-8.61	0.69	0.69	0.47	0.47
0.3	4.33	1.32	0.01	1.05	-0.01	31.54	30.71	21.28	22.23	-12.65	-12.32	-8.54	-8.92	1.99	1.94	1.39	1.45
0.5	4.26	2.17	0.03	1.61	-0.04	32.33	29.93	20.37	23.12	-12.99	-12.02	-8.18	-9.29	3.11	2.89	2.13	2.42
0.7	4.19	3.02	0.06	2.04	-0.11	33.02	29.27	19.59	23.88	-13.28	-11.78	-7.88	-9.61	4.05	3.60	2.61	3.18
0.9	4.12	3.85	0.09	2.34	-0.20	33.54	28.77	19.00	24.46	-13.51	-11.59	-7.66	-9.85	4.67	4.02	2.89	3.71
1.1	4.04	4.66	0.13	2.56	-0.30	33.88	28.45	18.61	24.82	-13.67	-11.48	-7.51	-10.02	5.20	4.38	3.11	4.13
1.3	3.97	5.46	0.16	2.72	-0.39	34.16	28.19	18.29	25.12	-13.81	-11.40	-7.40	-10.15	5.66	4.68	3.25	4.45
1.5	3.90	6.25	0.20	2.83	-0.48	34.39	27.98	18.03	25.36	-13.93	-11.34	-7.30	-10.27	6.03	4.92	3.35	4.70
1.7	3.83	7.02	0.24	2.90	-0.55	34.57	27.82	17.83	25.54	-14.12	-11.38	-7.29	-10.43	6.31	5.09	3.41	4.88
1.9	3.75	7.78	0.28	2.94	-0.60	34.75	27.76	17.63	25.62	-14.34	-11.46	-7.28	-10.57	6.53	5.22	3.44	4.99
2.1	3.68	8.52	0.32	2.96	-0.65	34.90	27.74	17.46	25.65	-14.54	-11.57	-7.28	-10.69	6.69	5.32	3.44	5.05
2.3	3.60	9.25	0.35	2.97	-0.68	35.03	27.75	17.33	25.66	-14.77	-11.71	-7.32	-10.82	6.80	5.39	3.43	5.08
2.5	3.52	9.96	0.39	2.96	-0.71	35.14	27.79	17.21	25.61	-15.12	-11.96	-7.41	-11.02	6.87	5.44	3.41	5.08
2.7	3.44	10.65	0.43	2.95	-0.72	35.30	27.91	17.05	25.50	-15.49	-12.25	-7.49	-11.19	6.94	5.49	3.38	5.05
2.9	3.36	11.33	0.46	2.95	-0.72	35.45	28.04	16.90	25.37	-15.88	-12.56	-7.57	-11.36	6.98	5.53	3.33	5.00
3.1	3.27	11.99	0.50	2.94	-0.72	35.59	28.19	16.76	25.22	-16.43	-13.01	-7.73	-11.64	7.02	5.56	3.29	4.95
3.3	3.18	12.64	0.53	2.94	-0.71	35.80	28.41	16.55	25.00	-17.08	-13.54	-7.89	-11.93	7.06	5.60	3.23	4.89
3.5	3.09	13.27	0.56	2.94	-0.70	36.05	28.66	16.31	24.74	-17.78	-14.13	-8.04	-12.21	7.11	5.65	3.17	4.81
3.7	2.99	13.87	0.59	2.95	-0.68	36.30	28.93	16.05	24.48	-18.33	-14.60	-8.10	-12.36	7.17	5.71	3.11	4.74
3.9	2.89	14.46	0.62	2.97	-0.66	36.49	29.12	15.87	24.28	-18.79	-14.99	-8.17	-12.51	7.21	5.75	3.07	4.70
4.1	2.78	15.03	0.65	2.99	-0.64	36.65	29.29	15.71	24.12	-19.24	-15.38	-8.25	-12.66	7.24	5.78	3.04	4.67
4.3	2.67	15.57	0.68	3.02	-0.62	36.81	29.46	15.55	23.96	-19.32	-15.46	-8.16	-12.58	7.27	5.81	3.02	4.65
4.5	2.56	16.09	0.71	3.05	-0.60	36.81	29.44	15.54	23.96	-19.33	-15.46	-8.16	-12.58	7.28	5.82	3.03	4.68
4.7	2.45	16.59	0.73	3.08	-0.60	36.82	29.43	15.53	23.98	-19.33	-15.45	-8.15	-12.59	7.28	5.82	3.06	4.72
4.9	2.34	17.07	0.76	3.10	-0.59	36.84	29.42	15.51	23.99	-19.34	-15.45	-8.14	-12.59	7.30	5.83	3.08	4.76
5.1	2.22	17.53	0.79	3.12	-0.60	36.85	29.40	15.49	24.01	-19.35	-15.44	-8.13	-12.60	7.33	5.85	3.10	4.80
5.3	2.11	17.96	0.81	3.14	-0.60	36.87	29.38	15.47	24.03	-19.36	-15.43	-8.12	-12.62	7.37	5.87	3.11	4.82
5.5	2.00	18.37	0.83	3.15	-0.60	36.89	29.37	15.45	24.05	-19.37	-15.42	-8.11	-12.63	7.39	5.89	3.11	4.84
5.7	1.89	18.76	0.85	3.16	-0.61	36.90	29.36	15.44	24.06	-19.37	-15.41	-8.11	-12.63	7.41	5.90	3.12	4.86
5.9	1.78	19.12	0.87	3.16	-0.61	36.91	29.35	15.43	24.07	-19.38	-15.41	-8.10	-12.64	7.43	5.91	3.12	4.86
6.1	1.67	19.47	0.89	3.16	-0.61	36.91	29.34	15.43	24.08	-19.38	-15.41	-8.10	-12.64	7.43	5.91	3.11	4.86
6.3	1.55	19.79	0.91	3.15	-0.61	36.91	29.34	15.42	24.08	-19.38	-15.40	-8.10	-12.64	7.43	5.91	3.11	4.86
6.5	1.44	20.09	0.93	3.15	-0.61	36.91	29.34	15.43	24.08	-19.38	-15.41	-8.10	-12.64	7.43	5.91	3.11	4.85
6.7	1.33	20.36	0.94	3.15	-0.61	36.91	29.34	15.43	24.08	-19.38	-15.41	-8.10	-12.64	7.43	5.91	3.11	4.86
6.9	1.22	20.62	0.96	3.15	-0.61	36.91	29.35	15.43	24.07	-19.38	-15.41	-8.10	-12.64	7.43	5.91	3.11	4.85
7.1	1.11	20.85	0.97	3.15	-0.62	36.91	29.35	15.43	24.07	-19.38	-15.41	-8.10	-12.64	7.43	5.90	3.11	4.85
7.3	0.99	21.06	0.98	3.15	-0.62	36.91	29.35	15.43	24.07	-19.38	-15.41	-8.10	-12.64	7.43	5.90	3.11	4.85
7.5	0.88	21.25	0.99	3.15	-0.62	36.91	29.35	15.43	24.07	-19.38	-15.41	-8.10	-12.64	7.42	5.90	3.11	4.85
7.7	0.77	21.41	1.00	3.15	-0.62	36.91	29.35	15.43	24.07	-19.38	-15.41	-8.10	-12.64	7.43	5.90	3.11	4.85
7.9	0.66	21.56	1.01	3.15	-0.62	36.91	29.35	15.43	24.07	-19.38	-15.41	-8.10	-12.64	7.43	5.90	3.11	4.85
8.1	0.55	21.68	1.01	3.15	-0.62	36.91	29.35	15.43	24.07	-19.38	-15.41	-8.10	-12.64	7.43	5.90	3.11	4.86
8.3	0.44	21.77	1.02	3.14	-0.62	36.91	29.35	15.43	24.07	-19.38	-15.41	-8.10	-12.64	7.43	5.90	3.11	4.85
8.5	0.32	21.85	1.02	3.14	-0.62	36.91	29.35	15.43	24.07	-19.38	-15.41	-8.10	-12.64	7.42	5.90	3.11	4.85
8.7	0.21	21.90	1.03	3.14	-0.62	36.91	29.35	15.43	24.07	-19.38	-15.41	-8.10	-12.64	7.43	5.90	3.11	4.85
8.9	0.10	21.94	1.03	3.14	-0.62	36.91	29.35	15.43	24.07	-19.38	-15.41	-8.10	-12.64	7.43	5.90	3.11	4.86

TABLE 9. BRAKING WHILE COASTING ON HORIZONTAL PLANE WITH 10 DEG SIDE SLOPE

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	4.44	0.00	0.00	0.00	0.00	30.00	30.00	25.00	25.00	-12.00	-12.00	-10.00	-10.00	0.00	0.00	0.00	0.00
0.1	4.37	0.44	0.00	0.37	0.00	31.74	31.74	21.93	21.93	-12.72	-12.72	-8.78	-8.78	0.71	0.71	0.49	0.49
0.3	4.24	1.30	0.01	1.07	-0.01	32.02	31.16	21.59	22.67	-12.87	-12.52	-8.68	-9.07	2.06	2.00	1.44	1.50
0.5	4.11	2.14	0.03	1.66	-0.04	32.85	30.37	20.64	23.48	-13.24	-12.24	-8.32	-9.46	3.24	3.00	2.22	2.52
0.7	3.98	2.95	0.06	2.11	-0.11	33.58	29.68	19.81	24.27	-13.57	-12.00	-8.01	-9.81	4.22	3.74	2.72	3.32
0.9	3.86	3.73	0.09	2.44	-0.20	34.13	29.17	19.18	24.86	-13.88	-11.88	-7.82	-10.11	4.90	4.20	3.03	3.91
1.1	3.72	4.49	0.12	2.70	-0.31	34.54	28.85	18.72	25.23	-14.29	-11.96	-7.76	-10.44	5.50	4.61	3.26	4.37
1.3	3.59	5.22	0.16	2.89	-0.40	34.96	28.66	18.26	25.46	-14.75	-12.14	-7.73	-10.74	6.04	4.97	3.40	4.73
1.5	3.46	5.92	0.20	3.03	-0.48	35.35	28.55	17.84	25.61	-15.44	-12.50	-7.81	-11.18	6.49	5.26	3.48	4.99
1.7	3.32	6.60	0.23	3.12	-0.55	35.78	28.60	17.38	25.59	-16.21	-13.00	-7.90	-11.59	6.88	5.51	3.50	5.16
1.9	3.17	7.25	0.27	3.19	-0.60	36.20	28.72	16.94	25.48	-17.31	-13.77	-8.12	-12.19	7.20	5.72	3.48	5.23
2.1	3.02	7.87	0.30	3.23	-0.63	36.71	29.03	16.41	25.19	-18.42	-14.57	-8.24	-12.64	7.48	5.92	3.41	5.23
2.3	2.86	8.45	0.34	3.27	-0.64	37.16	29.33	15.95	24.90	-19.22	-15.17	-8.25	-12.88	7.71	6.09	3.32	5.18
2.5	2.70	9.01	0.37	3.30	-0.64	37.46	29.54	15.64	24.70	-19.67	-15.51	-8.21	-12.97	7.86	6.20	3.26	5.15
2.7	2.53	9.53	0.40	3.32	-0.63	37.61	29.63	15.49	24.61	-19.75	-15.56	-8.13	-12.92	7.93	6.25	3.23	5.14
2.9	2.36	10.02	0.43	3.34	-0.62	37.63	29.62	15.47	24.62	-19.76	-15.55	-8.12	-12.93	7.94	6.25	3.24	5.16
3.1	2.19	10.47	0.45	3.36	-0.62	37.64	29.61	15.46	24.63	-19.76	-15.55	-8.12	-12.93	7.94	6.25	3.26	5.19
3.3	2.02	10.89	0.48	3.38	-0.62	37.65	29.60	15.45	24.64	-19.76	-15.54	-8.11	-12.94	7.96	6.26	3.28	5.22
3.5	1.85	11.28	0.50	3.39	-0.62	37.66	29.59	15.44	24.66	-19.77	-15.53	-8.10	-12.95	7.98	6.28	3.29	5.25
3.7	1.68	11.63	0.52	3.40	-0.62	37.67	29.58	15.42	24.67	-19.78	-15.53	-8.10	-12.95	8.01	6.29	3.29	5.27
3.9	1.51	11.95	0.54	3.41	-0.63	37.68	29.56	15.41	24.69	-19.78	-15.52	-8.09	-12.96	8.03	6.30	3.30	5.28
4.1	1.34	12.23	0.56	3.41	-0.63	37.69	29.56	15.40	24.70	-19.79	-15.52	-8.08	-12.97	8.04	6.31	3.30	5.29
4.3	1.17	12.48	0.57	3.41	-0.63	37.70	29.55	15.39	24.70	-19.79	-15.51	-8.08	-12.97	8.05	6.31	3.29	5.29
4.5	0.99	12.70	0.58	3.41	-0.63	37.70	29.55	15.39	24.70	-19.79	-15.51	-8.08	-12.97	8.05	6.31	3.29	5.28
4.7	0.82	12.88	0.60	3.41	-0.63	37.70	29.55	15.39	24.70	-19.79	-15.51	-8.08	-12.97	8.05	6.31	3.29	5.28
4.9	0.65	13.03	0.60	3.41	-0.63	37.70	29.55	15.39	24.70	-19.79	-15.51	-8.08	-12.97	8.05	6.31	3.29	5.28
5.1	0.48	13.14	0.61	3.40	-0.63	37.69	29.55	15.39	24.70	-19.79	-15.52	-8.08	-12.97	8.04	6.31	3.29	5.27
5.3	0.31	13.22	0.62	3.40	-0.63	37.69	29.55	15.40	24.70	-19.79	-15.52	-8.08	-12.97	8.04	6.31	3.29	5.28
5.5	0.14	13.26	0.62	3.41	-0.63	37.69	29.55	15.40	24.70	-19.79	-15.52	-8.08	-12.97	8.04	6.31	3.29	5.28

STEERING EFFECTS

Front-Wheel Steering Failure on Horizontal Plane (Driving at 400 W, Fig. 10)

The vehicle is in straight-ahead motion at $v_o = 2.22$ m/s (8 km/hr). At $t = 0.3$ s, failure of an electronic component in the steering circuit causes the front wheels to go into a hard-over position to the right within 3 s, beginning at $t = 0.3$ s. Full hard-over position is reached at $t = 3.5$ s and remains unchanged for the remainder of the motion.

No countermeasures are taken by the astronaut; the drive system remains under power at 400 W.

The vehicle goes into right turn of decreasing turn radius with $R_m = 0.66$ m reached at $t = 8.7$ s.

The vehicle's speed decreases continuously because of the skidding resistance (up to 50-deg yaw angle at $t = 7.5$ s).

$v_{min} = 0.91$ m/s at $t = 8.7$ s.

Maximum side load on wheel is $S_3 = 35$ kg (77 lb) at 9.5 s.

Table 10 gives numerical values of the front-wheel steering failure.

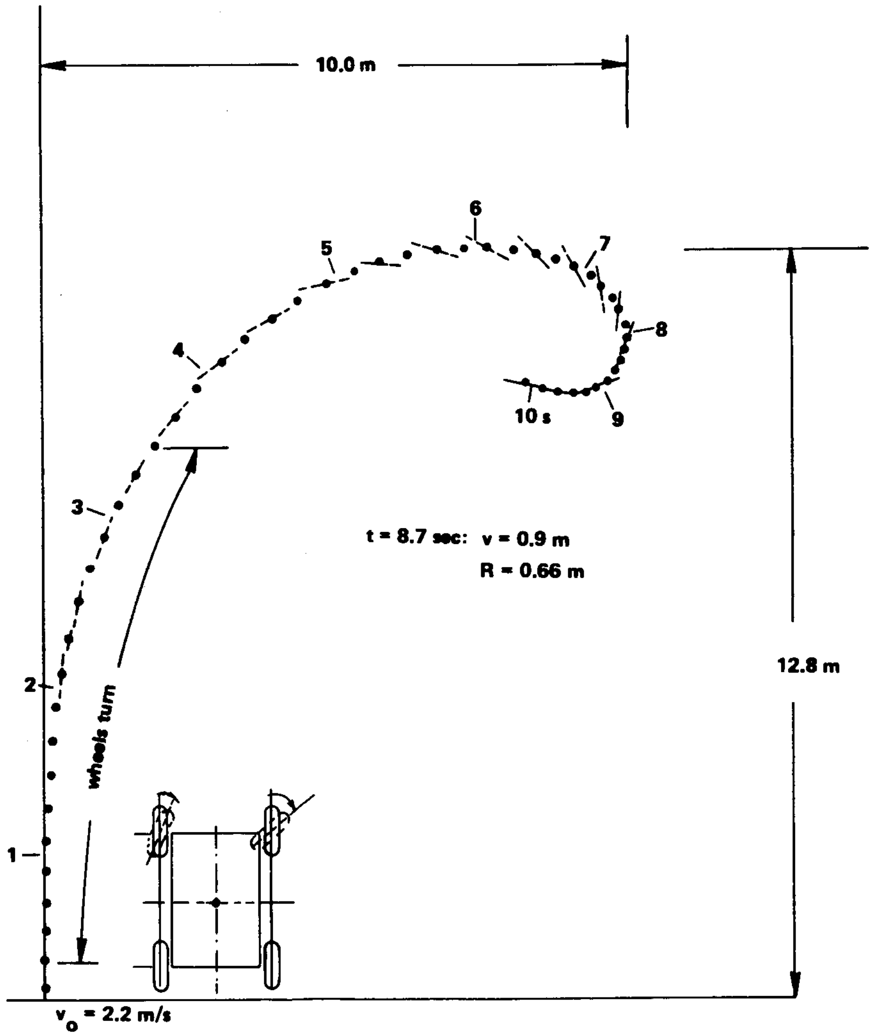


Figure 10. Front-wheel steering failure on horizontal plane, (driving at 400 W).

Front-Wheel Steering Failure on Horizontal Plane with Countersteering at $t = 2.1$ s (Driving at 400 W, Fig. 11)

The vehicle is in straight-ahead motion at $v_o = 2.22$ m/s (8 km/hr). At $t = 0.3$ s, failure of an electronic component in the steering circuit causes the front wheels to move into a hard-over position to the right within 3 s. Full hard-over position of the front wheels is reached at $t = 3.5$ s and remains unchanged for the remainder of the motion.

It is assumed that at $t = 2.1$ s (when the vehicle axis deviates by 15 deg from the initial straight-ahead course), the astronaut initiates a left-turn correction and increases to full hard-over condition of the rear wheels by $t = 4.9$ s. All wheels remain in their extreme positions for the remainder of the motion. Drive system remains under power at 400 W.

Countersteering moment produced by the rear wheels is insufficient to bring the vehicle back to the original straight course, it can only keep the vehicle from going into a tight turn as shown in Figure 10. The corridor width is increased from 10.0 to 11.7 m. At $t = 10$ s, the vehicle would begin to follow an almost straight path, opposite the original direction.

If brakes had been applied and power reduced to "zero" at $t = 2.1$ s ($v = 11$ km/hr), the vehicle would have come to rest after 3.8 s (at $t = 5.9$ s) and a distance of 6 m (values taken from Fig. 8).

Table 11 presents numerical values of this case.

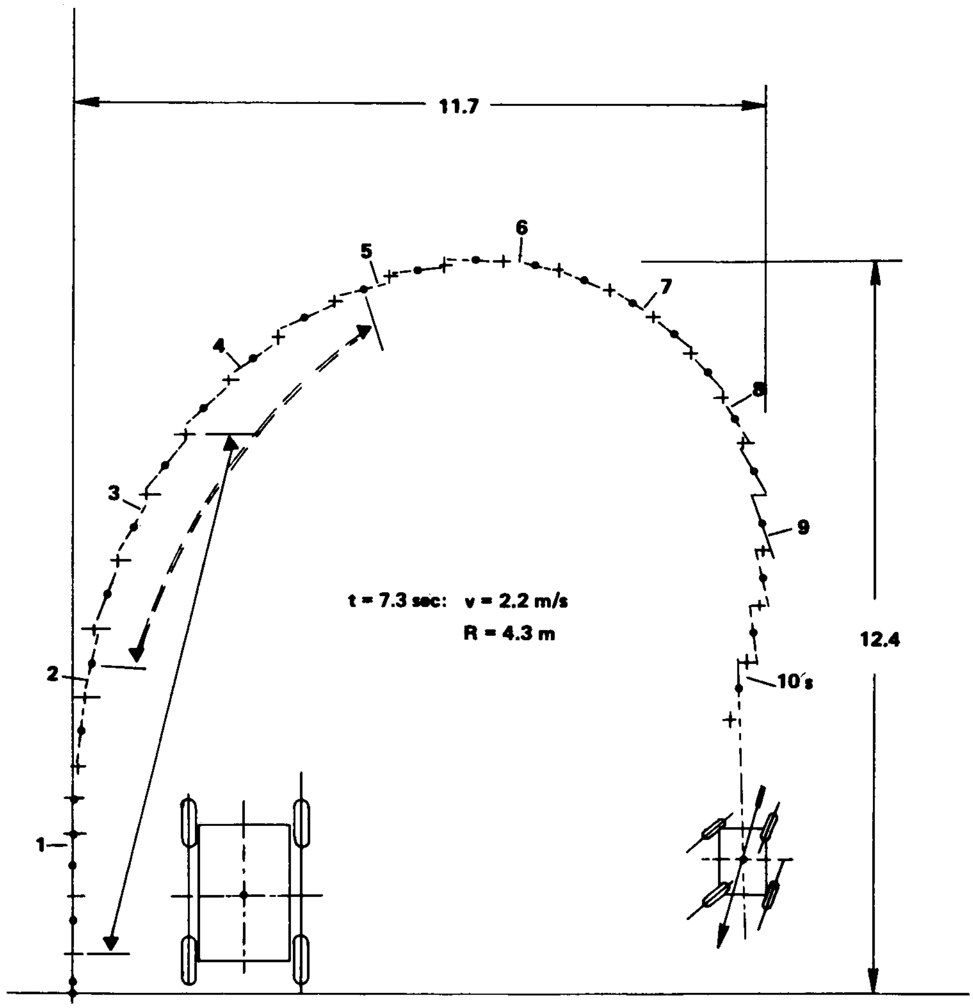


Figure 11. Front-wheel steering failure on horizontal plane with countersteering (driving at 400 W).

Front-Wheel Steering Failure on Sloping Terrain (Driving at 400 W, Fig. 12)

The vehicle is in straight-ahead motion (in Y-direction) at $v_o = 2.22$ m/s (8 km/hr). At $t = 0.3$ s, failure of an electronic component in the steering circuit causes the front wheels to go into a hard-over position to the right within 3 s, beginning at $t = 0.3$ s, reaching full hard-over position at $t = 3.5$ s, and remaining unchanged for the remainder of the motion.

No countermeasures are taken by the astronaut; the drive system remains under power at 400 W.

Downslope and side slope add an additional displacement to the motion in the two directions and cause the vehicle to skid at larger angles for greater parts of the motion. Brake application after $t = 5$ s apparently would be ineffective, since the vehicle has turned almost 90 deg to the path and moves primarily in a lateral direction. After turning more than 90 deg, application of power to the drive system might be more effective in bringing the vehicle to a stop.

Brake application at a time as early as $t = 2.5$ or 3.0 s appears to be the proper response to this type of steering failure, especially on a downhill slope. The failure occurring on a horizontal plane seems to be the least critical with respect to brake application and space required to bring the vehicle to a stop.

Maximum side load on wheels (cornering forces) S_3 ranged from 35.5 to 37.2 kg depending on degree of slope.

Tables 12 through 15 present numerical values of this front-wheel steering failure on sloping terrain (driving at 400 W).

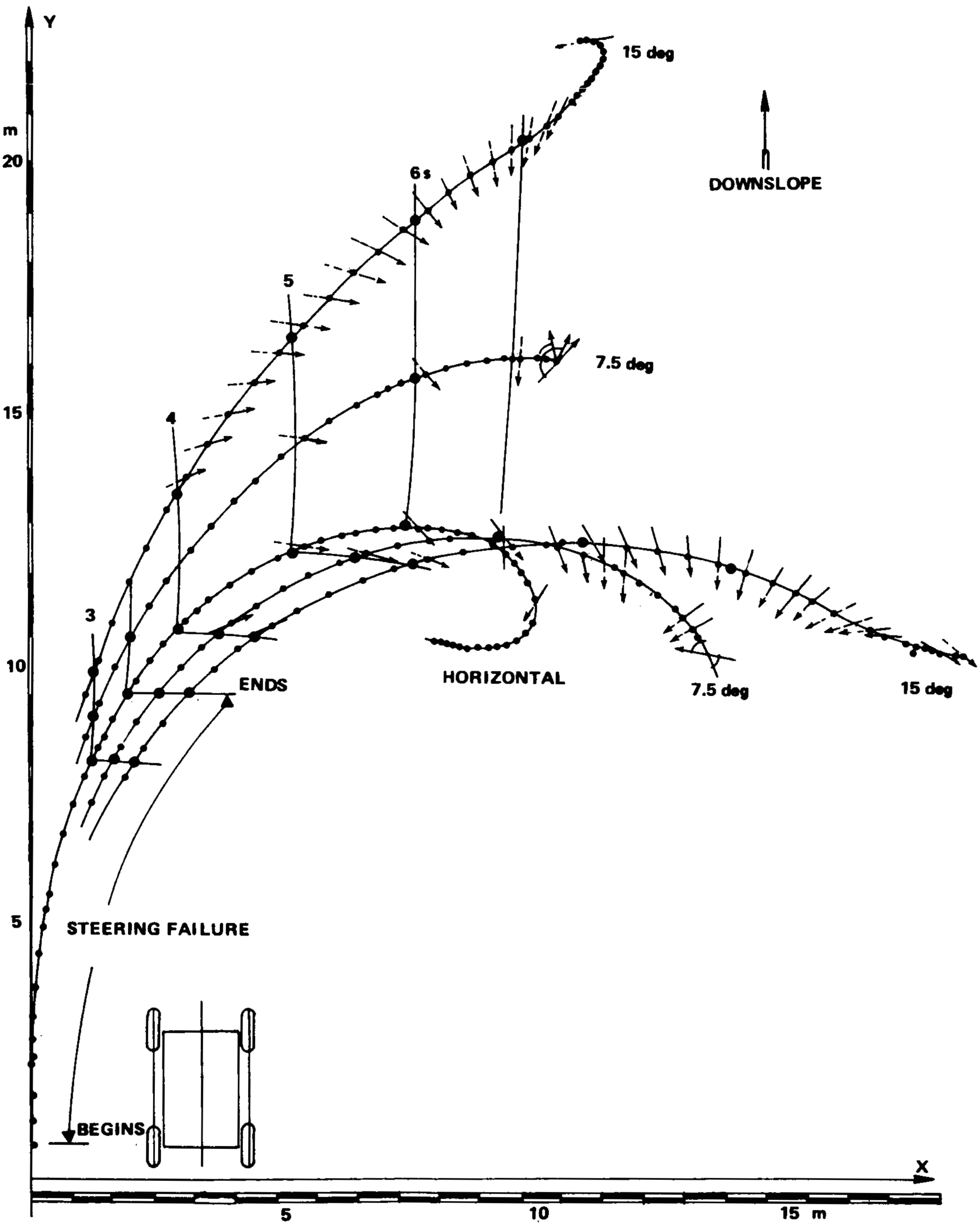


Figure 12. Front-wheel steering failure on slopes (driving at 400 W).

Front-Wheel Steering Failure on Sloping Terrain with Countersteering (Driving at 400 W, Fig. 13)

The vehicle is in straight-ahead motion (in Y-direction) at $v_o = 2.22$ m/s (8 km/hr). At $t = 0.3$ s, failure of an electronic component in the steering circuit causes the front wheels to go into a hard-over position to the right within 3 s, beginning at $t = 0.3$ s, reaching full hard-over position at $t = 3.5$ s, and remaining unchanged for the remainder of the motion.

It is assumed that at time $t = 2.1$ s (when the vehicle axis deviates by 15 deg from the initial straight-ahead direction), the astronaut initiates a left-turn correction and increases to full hard-over condition of the rear wheels by $t = 4.9$ s. All wheels remain in their extreme positions for the remainder of the motion. The drive system remains under power at 400 W.

When comparing Figure 13 with Figure 12, it will be immediately apparent that countersteering would not alleviate the situation in any way. In case of the forward-sloping terrain, there is hardly any effect noticeable between the cases with and without countersteering, while actually more room will be required in both directions in case of the side-sloping terrain. Thus, countersteering by itself does not appear to be a proper response to steering failure in sloping terrain.

It should be noted that the vehicle remains at smaller yaw angles over longer periods of time, which lets brake application appear to be more effective, especially in the case of side slopes and to some lesser degree also in case of the forward-sloping terrain.

Maximum wheel side loads (S_3) range from 30.8 to 34.9 kg.

Tables 16 through 19 present the numerical values pertaining to this case of front-wheel steering failure on sloping terrain with countersteering (driving at 400 W).

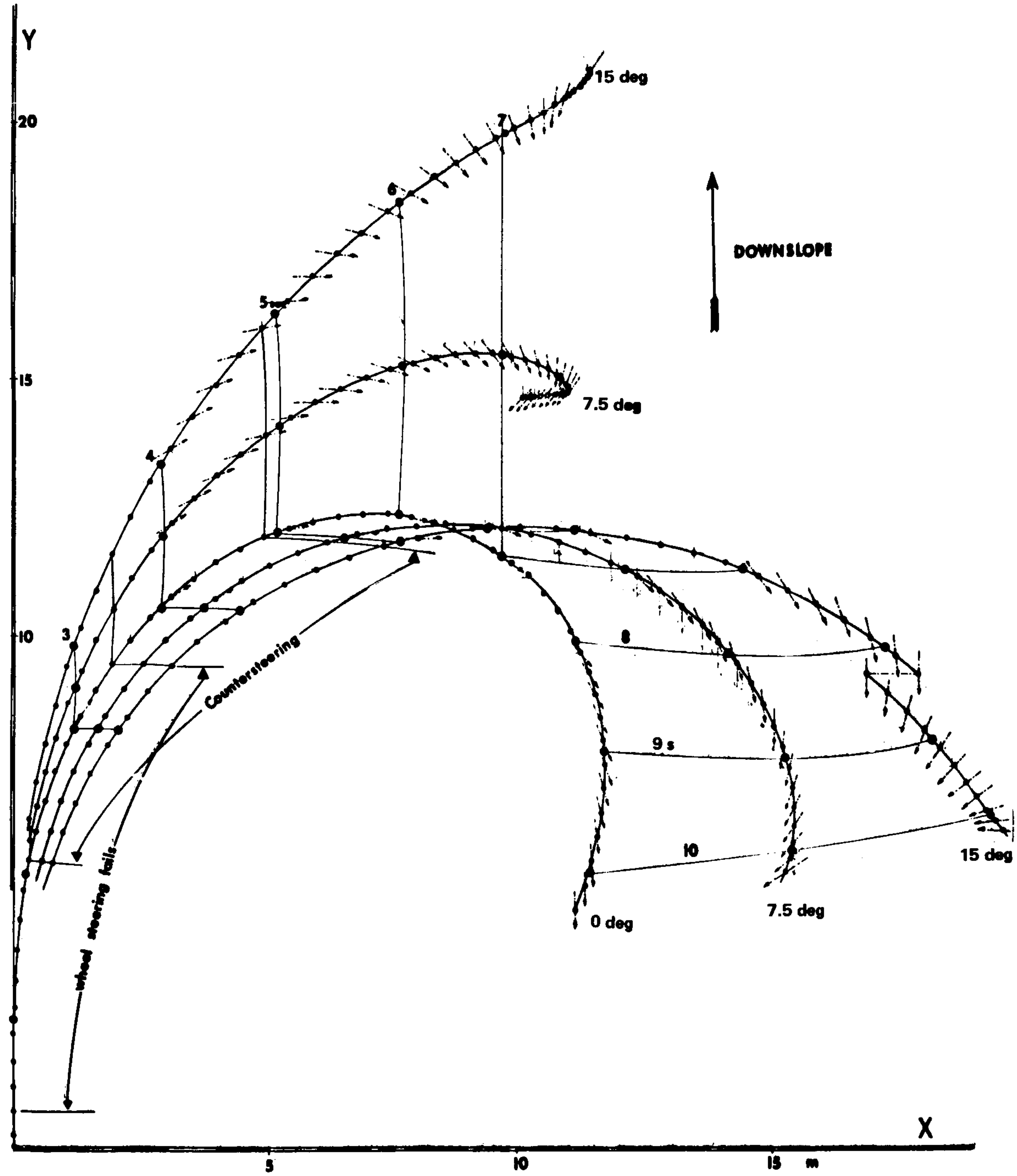


Figure 13. Front-wheel steering failure on slopes with countersteering (driving at 400 W).

Rear-Wheel Steering Failure While Coasting (Fig. 14)

The failure of an electric component in the steering circuit may also cause the rear wheels to move into a hard-over position.

The vehicle is assumed to be in a straight-ahead motion at $v_o = 4.44$ m/s (16 km/hr) at time $t = 0$. At this time, the hand-controller is set to "neutral" (no power to drive motors). The vehicle will then coast, subjected only to the decelerating forces from the rolling resistance, back-drive torque of the drive system and some brake application at a speed of about 12 km/hr. Presently, these forces are not well known. These force coefficients were assumed to represent this particular condition: $\mu = 0.20$ at $v = 0$; $\mu = 0.23$ at $v = 4$ km/hr; $\mu = 0.32$ at $v = 8$ km/hr, and $\mu = 0.465$ at $v = 11.6$ km/hr. At speeds higher than 11.6 km/hr, the coefficient μ will drop to a value of 0.40. (Values are shown as dashed curve in Fig. 3.)

Figure 14 shows that the vehicle would continue to move straight ahead, coming to a stop after 6.9 s and a distance of 13.2 m, with a sideways displacement of 1.6 m. The vehicle would have rotated at this point about its vertical axis by an angle of slightly more than 90 deg.

Maximum wheel side load is 30 kg.

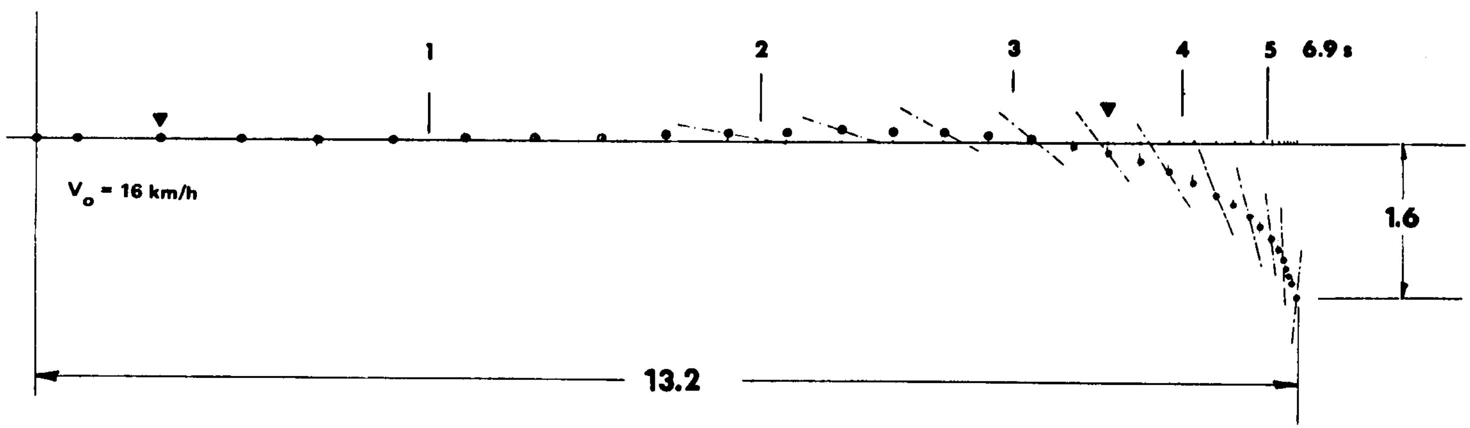


Figure 14. Rear-wheel steering failure while coasting.

Four-Wheel Steering Failure (Fig. 15)

Although a four-wheel steering failure has a low probability of occurring, it has been assumed to happen as a matter of interest.

The vehicle is assumed to be in a straight-ahead motion at time $t = 0$. At this instant, the hand-controller is set to "neutral"; the vehicle will then coast and be subjected only to the decelerating forces from rolling resistance, back-drive torque of the drive system, and some brake application. Presently, these forces are not well known. They have been assumed to be presented by these force coefficients: $\mu = 0.20$ at $v = 0$, $\mu = 0.23$ at $v = 4$ km/hr, $\mu = 0.32$ at $v = 8$ km/hr, and $\mu = 0.465$ at $v = 16$ km/hr. At speeds higher than 11.6 km/hr, the coefficient μ will drop to a value of 0.40. (Values are shown as dashed curve in Fig. 3.)

Two initial velocities were considered: $v_o = 16$ km/hr and $v_o = 16$ km/hr.

Front and rear wheels would begin to move into their hard-over position at time $t = 0.3$; they would reach the end position time $t = 3.5$ s. The vehicle would coast to a stop at these values:

	$v_o = 16$ km/hr	$v_o = 8$ km/hr
Distance (Y m)	11.7	4.8
Time (s)	5.1	4.3
Sideways displacement (m)	1.3	0.7
Maximum wheel side load (kg)	23.5	12.3

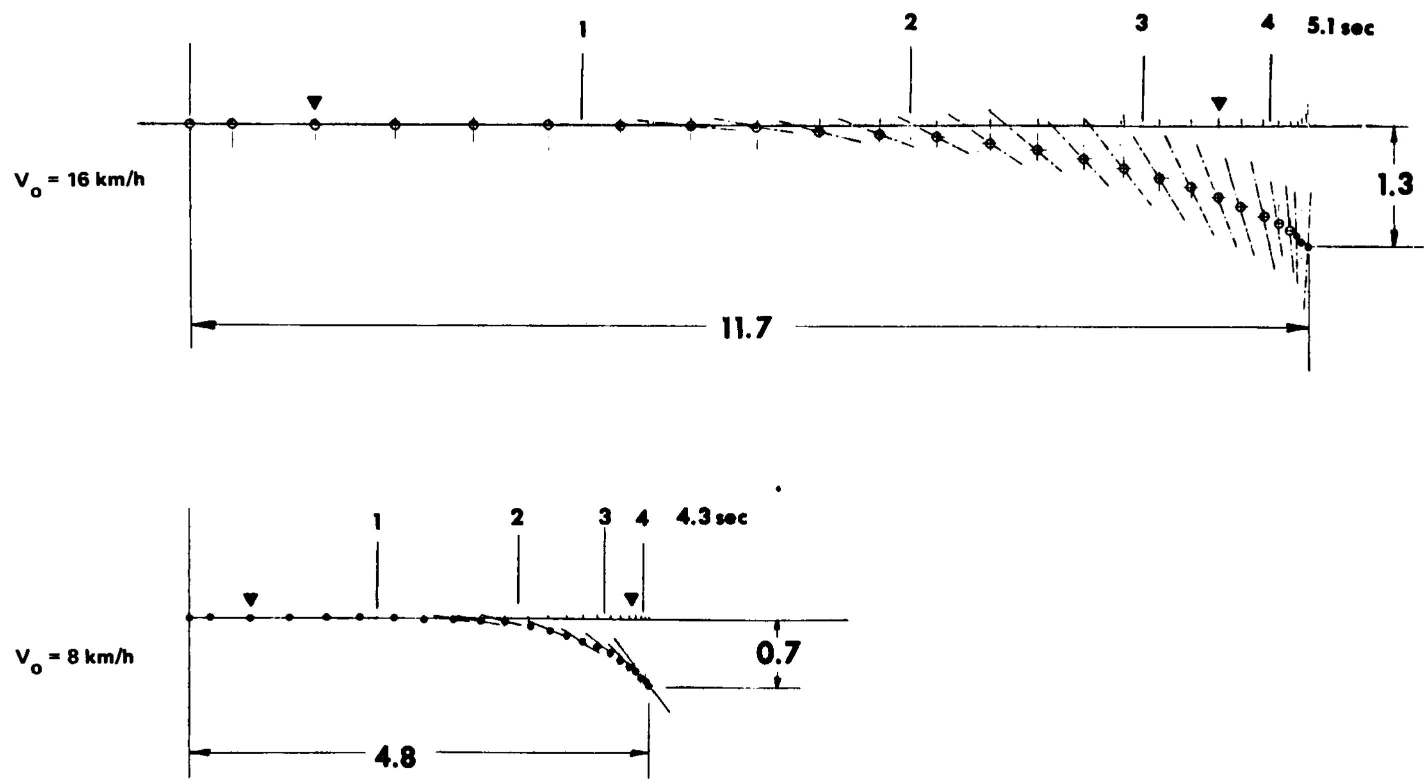


Figure 15. Four-wheel steering failure while coasting.

Four- and Two-Wheel Steering (Figs. 16 through 18)

Motion of the LRV in turns is characterized by the relatively large yaw angle that the vehicle will make with the tangent to the path or course.

To illustrate the reduction in yaw angle when two-wheel steering would be used, the following steering program was applied to the two cases:

from $t = 0$ to 1.9 s	vehicle is on straight-ahead course
$t = 1.9$ to $t = 2.9$ s	wheels move into right turn from 0 deg to 10.5 and 15 deg, for outside and inside wheels, respectively
$t = 2.9$ to $t = 3.9$ s	"HOLD" — wheels remain in right-turn position
$t = 3.9$ to $t = 4.9$ s	wheels return to neutral
$t = 4.9$ to $t = 5.9$ s	wheel moves into left turn from 0 deg to 10.5 and 15 deg, for outside and inside, respectively
$t = 5.9$ to $t = 6.9$ s	"HOLD" — wheels remain in left-turn position
$t = 6.9$ to $t = 7.9$ s	wheels return to neutral.

Figures 16 and 18 show the large yaw angle under four-wheel steering up to 12 deg (for 200 W) and 23 deg (for 400 W), whereas the two-wheel steering requires only 3 deg (under 200 W) and 8 deg (under 400 W).

In case of two-wheel steering, the vehicle would remain aligned much closer with the course (or tangent to the path).

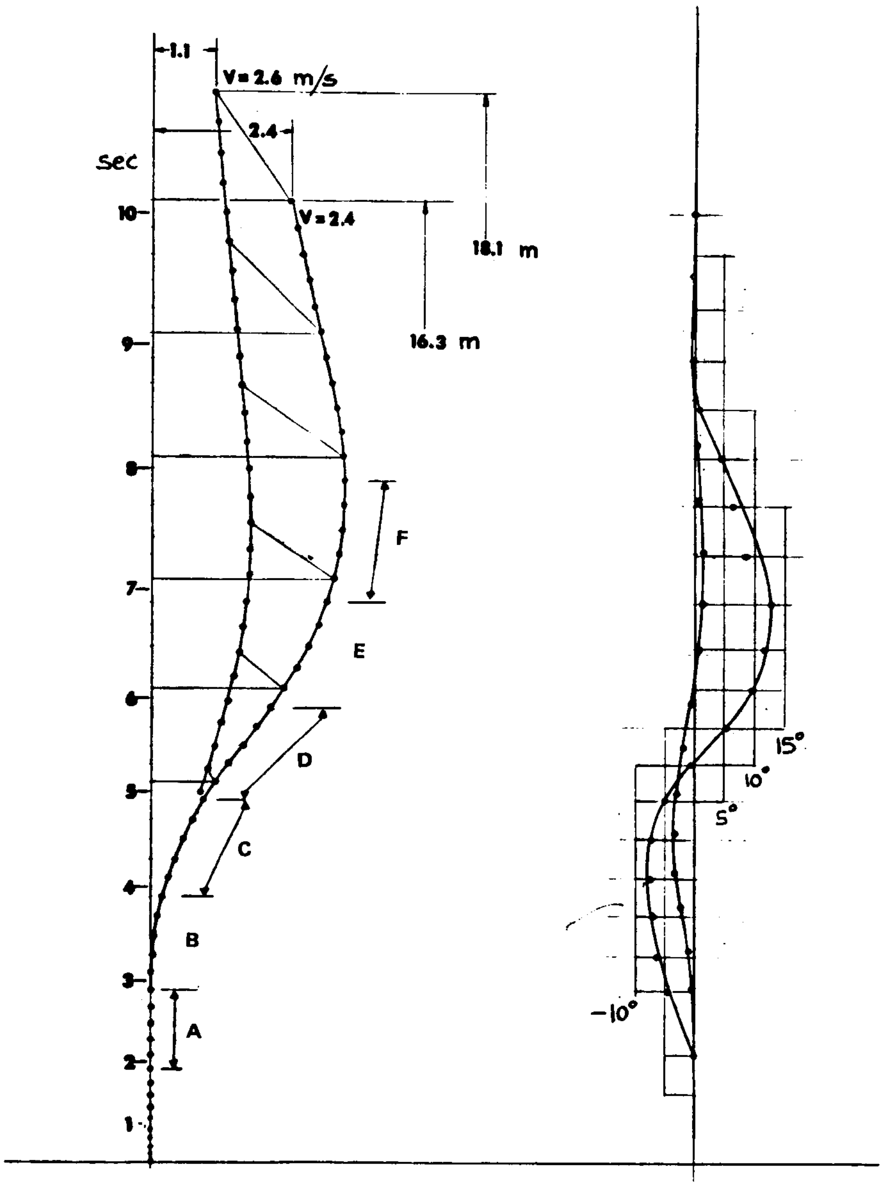


Figure 16. Driving at 200 W with two- and four-wheel steering programs.

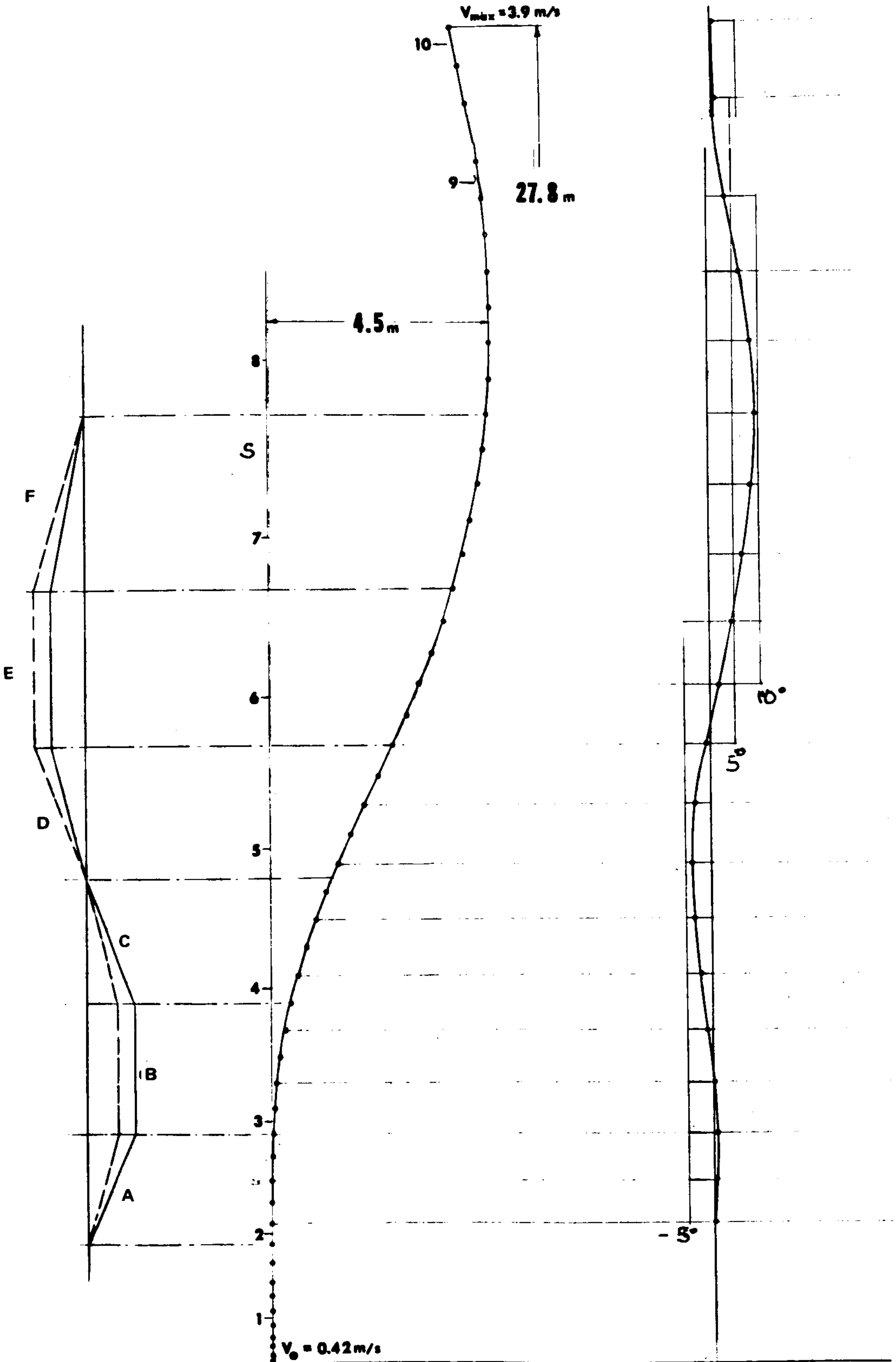


Figure 17. Driving at 400 W with two-wheel steering program.

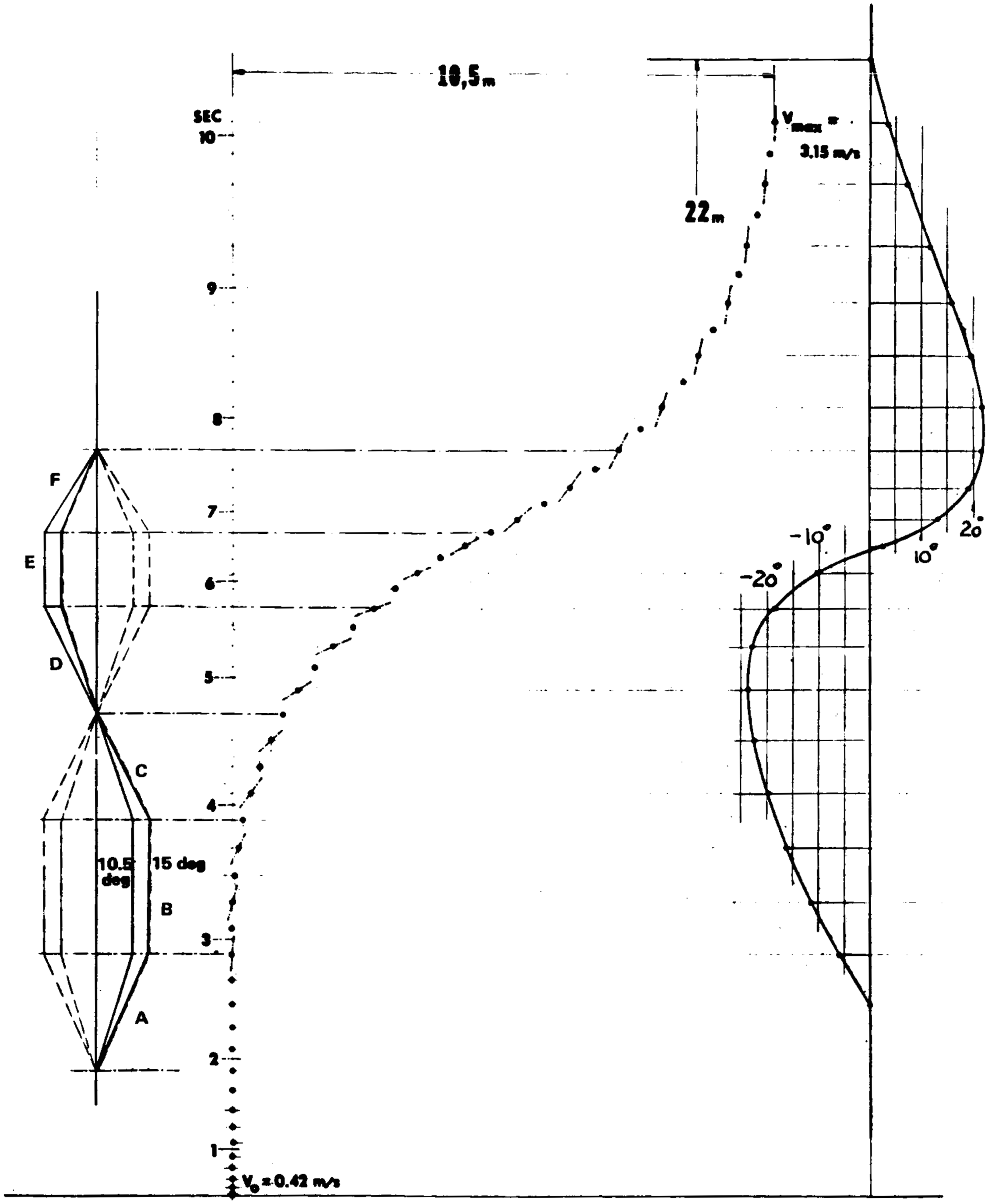


Figure 18. Driving at 400 W with four-wheel steering program.

TABLE 10. FRONT-WHEEL STEERING FAILURE ON HORIZONTAL PLANE (DRIVING AT 400 W)

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	2.22	0.00	0.00	0.00	0.00	24.00	24.00	31.00	31.00	7.15	7.15	9.23	9.23	0.00	0.00	0.00	0.00
0.1	2.27	0.22	0.00	0.00	0.00	20.45	20.45	34.05	34.05	5.94	5.94	9.90	9.90	0.00	0.00	0.00	0.00
0.3	2.37	0.69	0.00	0.00	0.00	20.61	20.61	33.89	33.89	5.70	5.70	9.37	9.37	0.00	0.00	0.00	0.00
0.5	2.46	1.17	0.00	0.00	0.00	20.85	20.85	33.65	33.66	5.48	5.48	8.85	8.85	2.12	1.91	0.00	0.00
0.7	2.55	1.67	0.00	0.15	0.05	20.32	21.86	34.29	32.53	5.14	5.48	8.56	8.19	4.86	4.91	0.26	0.25
0.9	2.63	2.19	0.00	0.68	0.35	19.42	23.38	35.36	30.84	4.80	5.52	8.30	7.55	6.34	6.01	1.36	1.23
1.1	2.71	2.72	0.02	1.58	1.12	18.84	24.58	36.07	29.51	4.60	5.41	7.88	7.11	7.28	7.11	3.45	3.01
1.3	2.78	3.27	0.04	2.81	2.47	18.07	26.01	37.00	27.92	4.39	5.32	7.51	6.64	8.01	8.25	5.71	4.65
1.5	2.84	3.83	0.07	4.39	4.41	17.36	27.41	37.87	26.37	4.22	5.23	7.15	6.20	8.67	9.65	7.91	6.09
1.7	2.90	4.40	0.13	6.30	6.88	16.68	28.79	38.68	24.85	4.09	5.19	6.87	5.79	9.10	10.99	10.15	7.38
1.9	2.95	4.98	0.20	8.51	9.84	16.06	30.05	39.44	23.45	4.01	5.16	6.62	5.43	9.45	12.36	12.39	8.37
2.1	2.99	5.57	0.30	10.98	13.24	15.50	31.22	40.12	22.15	3.98	5.15	6.40	5.11	9.70	13.91	14.53	9.06
2.3	3.02	6.16	0.43	13.71	17.04	14.99	32.33	40.74	20.93	4.01	5.19	6.22	4.82	9.81	15.58	16.41	9.62
2.5	3.05	6.74	0.59	16.64	21.20	14.55	33.34	41.30	19.82	4.09	5.26	6.08	4.59	9.85	17.13	18.29	9.98
2.7	3.06	7.32	0.78	19.78	25.70	14.13	34.24	41.80	18.82	4.23	5.38	5.98	4.40	9.81	18.47	20.13	10.14
2.9	3.07	7.89	1.00	23.08	30.51	13.78	35.02	42.24	17.96	4.41	5.56	5.95	4.26	9.64	19.85	21.72	10.30
3.1	3.07	8.45	1.26	26.54	35.60	13.44	35.71	42.66	17.19	4.67	5.80	5.98	4.16	9.41	21.11	23.02	10.34
3.3	3.06	8.99	1.55	30.13	40.96	13.14	36.27	43.01	16.57	5.00	6.11	6.07	4.12	9.20	22.30	24.36	10.40
3.5	3.03	9.50	1.87	33.86	46.55	12.81	36.82	43.41	15.97	5.34	6.49	6.23	4.09	8.97	23.32	25.58	10.36
3.7	3.00	9.99	2.23	37.70	52.38	12.51	37.27	43.76	15.46	5.52	6.83	6.47	4.13	8.75	23.96	26.76	10.30
3.9	2.96	10.45	2.61	41.67	58.43	12.08	37.50	44.23	15.18	5.66	7.19	6.79	4.24	8.46	24.48	27.85	10.34
4.1	2.92	10.88	3.01	45.77	64.68	11.65	37.67	44.71	14.97	5.80	7.64	7.17	4.38	8.16	24.88	28.86	10.38
4.3	2.87	11.27	3.44	50.00	71.12	11.21	37.76	45.18	14.84	5.91	8.12	7.62	4.56	7.85	25.24	29.78	10.39
4.5	2.81	11.61	3.89	54.36	77.74	10.78	37.81	45.65	14.75	6.06	8.64	8.13	4.77	7.55	25.57	30.63	10.33
4.7	2.74	11.92	4.35	58.86	84.52	10.36	37.82	46.11	14.72	6.01	9.17	8.70	5.05	7.25	25.76	31.38	10.30
4.9	2.67	12.18	4.83	63.50	91.45	9.97	37.75	46.51	14.76	5.80	9.71	9.37	5.39	6.98	25.90	32.02	10.33
5.1	2.60	12.40	5.31	68.28	98.55	9.62	37.64	46.88	14.85	5.61	10.30	10.10	5.76	6.74	26.00	32.64	10.40
5.3	2.51	12.57	5.79	73.21	105.80	9.24	37.51	47.28	14.97	5.40	10.89	10.89	6.17	6.47	26.06	33.10	10.48
5.5	2.43	12.69	6.27	78.31	113.20	8.88	37.32	47.65	15.15	5.19	11.46	11.70	6.74	6.22	26.06	33.36	10.60
5.7	2.33	12.76	6.74	83.60	120.76	8.53	37.07	48.01	15.39	4.98	11.98	12.56	7.41	5.97	25.95	33.61	10.77
5.9	2.23	12.79	7.19	89.10	128.49	8.17	36.78	48.37	15.67	4.77	12.52	13.50	8.12	5.72	25.75	33.86	10.97
6.1	2.13	12.78	7.63	94.84	136.37	7.80	36.46	48.75	15.99	4.65	13.06	14.44	8.92	5.46	25.52	34.13	11.19
6.3	2.03	12.72	8.04	100.87	144.39	7.40	36.12	49.15	16.32	4.32	13.53	15.39	9.48	5.18	25.29	34.40	11.42
6.5	1.92	12.63	8.42	107.22	152.56	7.06	35.83	49.49	16.61	4.12	13.96	16.29	9.67	4.94	25.08	34.65	11.63
6.7	1.81	12.50	8.77	113.93	160.86	6.79	35.60	49.77	16.84	3.97	14.33	17.29	9.82	4.75	24.84	34.84	11.79
6.9	1.69	12.34	9.08	121.05	169.29	6.54	35.35	50.02	17.08	3.82	14.61	18.23	9.98	4.58	24.44	35.02	11.96
7.1	1.57	12.15	9.35	128.65	177.87	6.32	35.09	50.23	17.35	3.69	14.85	19.08	10.13	4.43	23.95	35.16	12.14
7.3	1.45	11.95	9.57	136.83	186.60	6.14	34.83	50.41	17.61	3.59	15.03	19.83	10.29	4.30	23.27	35.28	12.33
7.5	1.33	11.73	9.74	145.68	195.48	6.01	34.55	50.53	17.91	3.51	15.08	20.47	10.46	4.21	22.27	35.37	12.53
7.7	1.22	11.51	9.87	155.36	204.49	5.94	34.23	50.58	18.25	3.47	15.01	20.97	10.66	3.47	20.81	35.40	12.77
7.9	1.11	11.29	9.95	166.01	213.59	5.96	33.68	50.52	18.84	3.48	14.76	21.45	11.00	4.07	18.66	35.36	13.19
8.1	1.02	11.08	9.98	177.92	222.59	5.97	31.43	50.34	21.25	3.49	13.86	21.91	12.41	4.14	15.93	35.24	14.87
8.3	0.96	10.89	9.96	191.22	231.13	5.88	30.87	50.40	21.85	3.44	13.81	22.46	12.76	3.59	14.71	35.28	15.29
8.5	0.92	10.71	9.90	205.75	238.96	5.82	30.67	50.45	22.06	3.40	13.84	22.83	12.88	1.84	13.59	35.32	15.44
8.7	0.91	10.56	9.80	221.18	246.02	5.85	30.77	50.43	21.95	3.42	13.80	22.89	12.82	1.06	12.19	35.30	15.36
8.9	0.93	10.44	9.67	236.92	252.38	6.05	31.11	50.24	21.60	3.53	13.63	22.60	12.61	2.21	9.95	34.06	15.12
9.1	0.98	10.36	9.50	251.95	258.13	6.64	30.71	49.58	22.07	3.87	12.94	21.83	12.88	2.84	6.57	31.35	15.45
9.3	1.07	10.32	9.30	265.00	263.32	7.57	29.82	48.52	23.09	4.39	12.11	20.69	13.44	3.66	3.57	26.56	15.80
9.5	1.20	10.32	9.07	275.27	267.97	8.82	28.72	47.11	24.35	4.79	11.21	19.37	14.19	4.71	1.41	19.11	13.58
9.7	1.34	10.36	8.82	282.48	272.17	10.96	26.94	44.68	26.41	5.58	9.99	17.69	14.41	6.28	0.91	10.70	9.31
9.9	1.48	10.43	8.55	286.93	276.19	13.58	25.29	41.76	28.37	6.52	8.78	15.44	14.62	8.06	1.69	7.40	7.27
10.1	1.61	10.53	8.25	289.88	280.42	14.82	25.36	40.43	28.40	6.80	8.10	13.79	13.81	8.99	2.97	9.19	9.28

TABLE 11. FRONT-WHEEL STEERING FAILURE WITH COUNTERSTEERING, 400 W, HORIZONTAL

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	2.22	0.00	0.00	0.00	0.00	24.00	24.00	31.00	31.00	7.15	7.15	9.23	9.23	0.00	0.00	0.00	0.00
0.1	2.27	0.22	0.00	0.00	0.00	20.45	20.45	34.05	34.05	5.94	5.94	9.90	9.90	0.00	0.00	0.00	0.00
0.3	2.37	0.69	0.00	0.00	0.00	20.61	20.61	33.89	33.89	5.70	5.70	9.37	9.37	0.00	0.00	0.00	0.00
0.5	2.46	1.17	0.00	0.00	0.00	20.85	20.85	33.65	33.65	5.48	5.48	8.85	8.85	2.12	1.91	0.00	0.00
0.7	2.55	1.67	0.00	0.15	0.05	20.32	21.86	34.29	32.53	5.14	5.48	8.56	8.19	4.86	4.91	0.26	0.26
0.9	2.63	2.19	0.00	0.68	0.36	19.42	23.38	35.36	30.84	4.80	5.52	8.30	7.65	6.34	6.01	1.36	1.23
1.1	2.71	2.72	0.02	1.58	1.12	18.84	24.58	36.07	29.51	4.60	5.41	7.88	7.11	7.28	7.11	3.45	3.01
1.3	2.78	3.27	0.04	2.81	2.47	18.07	26.01	37.00	27.92	4.39	5.32	7.51	6.64	8.01	8.25	5.71	4.65
1.5	2.84	3.83	0.07	4.39	4.41	17.35	27.41	37.87	26.37	4.22	5.23	7.15	6.20	8.67	9.65	7.91	6.09
1.7	2.90	4.40	0.13	6.30	6.88	16.68	28.79	38.68	24.85	4.09	5.19	6.87	5.79	9.10	10.99	10.15	7.38
1.9	2.95	4.98	0.20	8.51	9.84	16.06	30.05	39.44	23.45	4.01	5.16	6.62	5.43	9.45	12.35	12.39	8.37
2.1	2.99	5.57	0.30	10.98	13.24	15.50	31.22	40.12	22.15	3.98	5.15	6.40	5.11	9.70	13.91	14.53	9.06
2.3	3.02	6.16	0.43	13.71	17.04	14.99	32.33	40.74	20.93	4.01	5.19	6.29	4.87	9.81	15.58	18.05	10.39
2.5	3.05	6.74	0.59	16.72	21.17	14.16	33.92	41.75	19.17	3.98	5.37	6.47	4.59	9.60	17.43	22.24	11.06
2.7	3.06	7.32	0.78	20.09	25.51	13.44	35.66	42.64	17.26	4.00	5.70	6.71	4.29	9.33	19.21	24.64	10.82
2.9	3.05	7.89	1.01	23.74	29.93	13.18	36.73	43.00	16.09	4.16	6.01	7.03	4.19	9.22	20.69	26.14	10.60
3.1	3.04	8.44	1.27	27.55	34.36	13.03	37.64	43.23	15.10	4.38	6.36	7.39	4.16	9.12	21.95	27.26	10.28
3.3	3.01	8.96	1.57	31.50	38.79	12.96	38.35	43.35	14.33	4.69	6.71	7.77	4.20	9.07	22.97	28.07	9.98
3.5	2.98	9.46	1.90	35.57	43.23	12.93	38.95	43.42	13.69	5.02	7.08	8.14	4.28	9.05	23.88	28.60	9.59
3.7	2.94	9.93	2.26	39.75	47.68	12.95	39.41	43.44	13.19	5.09	7.34	8.53	4.42	9.06	24.20	28.99	9.24
3.9	2.89	10.36	2.65	44.03	52.16	12.89	39.61	43.52	12.98	5.14	7.56	8.98	4.71	9.02	24.30	29.41	9.08
4.1	2.85	10.76	3.07	48.41	56.70	12.81	39.79	43.62	12.78	5.17	7.80	9.44	5.01	8.97	24.37	29.72	8.96
4.3	2.80	11.12	3.50	52.89	61.28	12.74	39.93	43.70	12.63	5.21	8.04	9.90	5.33	8.92	24.39	30.00	8.84
4.5	2.74	11.44	3.96	57.48	65.90	12.67	40.06	43.78	12.48	5.24	8.28	10.36	5.78	8.87	24.37	30.27	8.73
4.7	2.69	11.71	4.43	62.19	70.55	12.58	40.19	43.89	12.34	5.26	8.52	10.82	6.22	8.81	24.32	30.54	8.64
4.9	2.64	11.94	4.91	67.03	75.23	12.50	40.31	43.99	12.20	5.28	8.76	11.28	6.62	8.75	24.23	30.78	8.54
5.1	2.59	12.12	5.40	71.99	79.90	12.43	40.42	44.07	12.07	5.30	9.00	11.76	7.01	8.70	24.10	30.85	8.46
5.3	2.53	12.26	5.89	77.09	84.57	12.40	40.50	44.11	11.99	5.32	9.22	12.21	6.97	8.68	23.90	30.88	8.39
5.5	2.48	12.35	6.38	82.31	89.22	12.48	40.56	44.02	11.94	5.37	9.41	12.40	6.94	8.74	23.62	30.82	8.36
5.7	2.43	12.39	6.87	87.64	93.88	12.43	40.46	44.07	12.04	5.36	9.54	12.60	7.00	8.70	23.18	30.85	8.43
5.9	2.38	12.39	7.35	93.08	98.55	12.40	40.35	44.10	12.15	5.33	9.64	12.77	7.07	8.68	22.60	30.87	8.50
6.1	2.34	12.34	7.82	98.63	103.23	12.39	40.22	44.10	12.29	5.31	9.72	12.90	7.15	8.67	21.98	30.81	8.60
6.3	2.30	12.25	8.27	104.28	107.90	12.41	40.08	44.07	12.44	5.28	9.77	13.00	7.23	8.68	21.34	30.66	8.71
6.5	2.27	12.11	8.71	110.00	112.54	12.45	39.92	44.02	12.61	5.25	9.81	13.05	7.33	8.71	20.67	30.48	8.83
6.7	2.24	11.94	9.13	115.77	117.15	12.50	39.76	43.95	12.78	5.21	9.82	13.08	7.43	8.75	19.84	30.26	8.96
6.9	2.22	11.72	9.52	121.58	121.72	12.59	39.57	43.84	13.00	5.20	9.81	13.06	7.55	8.81	18.94	30.00	9.10
7.1	2.21	11.47	9.88	127.40	126.21	12.70	39.37	43.71	13.22	5.18	9.77	13.00	7.68	8.89	17.86	29.70	9.26
7.3	2.20	11.19	10.22	133.20	130.62	12.84	39.12	43.54	13.49	5.17	9.72	12.91	7.80	8.92	16.73	29.33	9.46
7.5	2.20	10.87	10.52	138.95	134.93	13.00	38.86	43.34	13.80	5.15	9.64	12.78	7.72	8.97	15.56	28.82	9.66
7.7	2.20	10.53	10.79	144.60	139.11	13.25	38.55	43.06	14.14	5.16	9.54	12.60	7.64	9.09	14.39	28.24	9.90
7.9	2.21	10.16	11.03	150.12	143.15	13.61	38.26	42.76	14.47	5.16	9.43	12.40	7.58	9.21	13.06	27.55	10.13
8.1	2.22	9.76	11.23	155.50	147.06	13.80	37.91	42.42	14.86	5.17	9.28	12.16	7.54	9.36	11.69	26.78	10.40
8.3	2.24	9.35	11.40	160.69	150.82	14.12	37.56	42.05	15.26	5.17	9.12	11.89	7.47	9.51	10.25	25.97	10.68
8.5	2.26	8.92	11.53	165.67	154.44	14.47	37.19	41.66	15.69	5.17	8.94	11.61	7.40	9.67	8.80	24.95	10.98
8.7	2.29	8.47	11.63	170.44	157.92	14.84	36.77	41.22	16.16	5.18	8.75	11.30	7.33	9.86	7.44	23.95	11.31
8.9	2.32	8.02	11.68	174.97	161.26	15.22	36.40	40.80	16.58	5.18	8.55	10.99	7.24	10.05	6.13	22.87	11.61
9.1	2.35	7.55	11.71	179.28	164.48	15.60	36.02	40.36	17.02	5.17	8.33	10.67	7.14	10.24	4.95	21.83	11.91
9.3	2.39	7.08	11.70	183.36	167.60	15.98	35.67	39.93	17.42	5.18	8.12	10.34	7.11	10.44	3.73	20.88	12.20
9.5	2.42	6.60	11.65	187.23	170.63	16.33	35.33	39.53	17.81	5.18	7.90	10.09	7.08	10.62	2.50	19.94	12.47
9.7	2.46	6.12	11.57	190.90	173.59	16.67	34.99	39.14	18.20	5.18	7.68	9.75	7.05	10.79	1.49	19.03	12.74
9.9	2.50	5.63	11.47	194.38	176.49	16.99	34.70	38.78	18.53	5.18	7.47	9.47	7.02	10.96	0.69	18.21	12.97
10.1	2.53	5.15	11.33	197.69	179.33	17.28	34.46	38.45	18.81	5.16	7.27	9.21	6.96	11.11	0.08	17.42	13.17
10.3	2.57	4.67	11.16	200.86	182.19	17.54	34.26	38.15	19.05	5.14	7.07	8.96	6.91	11.26	0.43	16.80	13.33

TABLE 12. FRONT-WHEEL STEERING FAILURE ON 7.5 DEG SIDE SLOPE (DRIVING AT 400 W)

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	2.22	0.00	0.00	0.00	0.00	24.00	24.00	31.00	31.00	7.15	7.15	9.23	9.23	0.00	0.00	0.00	0.00
0.1	2.27	0.22	0.00	0.55	0.00	20.23	20.23	33.80	33.80	5.88	5.88	9.83	9.83	0.68	0.68	1.14	1.14
0.3	2.37	0.69	0.01	1.49	0.01	21.08	19.79	32.86	34.34	5.84	5.47	9.09	9.51	1.96	1.84	2.91	3.04
0.5	2.46	1.17	0.02	2.02	0.04	22.40	18.93	31.39	35.35	5.90	4.97	8.24	9.33	0.60	0.70	3.57	4.03
0.7	2.55	1.67	0.04	2.32	0.15	22.41	19.35	31.41	34.90	5.67	4.82	7.83	8.83	3.14	2.44	3.43	3.85
0.9	2.63	2.19	0.07	2.90	0.52	21.31	21.01	32.70	33.04	5.25	4.92	7.66	8.13	5.05	3.40	2.43	2.54
1.1	2.71	2.72	0.10	3.90	1.39	20.61	22.29	33.54	31.63	5.00	4.82	7.28	7.66	6.33	4.33	0.35	0.35
1.3	2.78	3.27	0.14	5.27	2.91	19.72	23.81	34.61	29.93	4.74	4.74	6.93	7.16	7.36	5.38	2.34	2.25
1.5	2.86	3.83	0.20	7.06	5.05	18.71	25.49	35.80	28.06	4.47	4.71	6.64	6.62	8.20	6.81	4.98	4.34
1.7	2.92	4.40	0.29	9.26	7.74	17.81	27.11	36.88	26.26	4.25	4.68	6.39	6.11	8.93	8.28	7.14	5.81
1.9	2.98	4.98	0.39	11.80	10.94	17.13	28.48	37.71	24.74	4.12	4.62	6.11	5.68	9.42	9.69	9.30	7.11
2.1	3.03	5.57	0.53	14.62	14.59	16.53	29.76	38.45	23.33	4.04	4.56	5.84	5.30	9.81	11.30	11.56	8.14
2.3	3.08	6.15	0.70	17.68	18.66	15.96	31.00	39.15	21.95	4.01	4.53	5.59	4.94	10.06	13.04	13.64	8.86
2.5	3.12	6.74	0.91	20.97	23.12	15.47	32.14	39.76	20.70	4.04	4.52	5.36	4.63	10.19	14.85	15.59	9.42
2.7	3.16	7.32	1.15	24.45	27.93	15.02	33.21	40.32	19.53	4.14	4.56	5.21	4.36	10.23	16.57	17.49	9.79
2.9	3.19	7.89	1.43	28.10	33.07	14.61	34.16	40.82	18.48	4.29	4.64	5.10	4.13	10.21	18.13	19.40	9.94
3.1	3.21	8.44	1.75	31.88	38.51	14.24	35.00	41.28	17.54	4.50	4.79	5.02	3.95	9.97	19.65	21.02	10.07
3.3	3.22	8.97	2.11	35.78	44.22	13.91	35.72	41.68	16.76	4.79	5.00	4.99	3.82	9.74	21.06	22.40	10.10
3.5	3.23	9.48	2.50	39.76	50.18	13.61	36.33	42.04	16.07	5.17	5.29	5.01	3.73	9.53	22.40	23.79	10.11
3.7	3.22	9.96	2.93	43.81	56.37	13.28	36.93	42.44	15.41	5.28	5.56	5.10	3.67	9.30	23.24	25.06	10.06
3.9	3.21	10.41	3.39	47.93	62.78	12.89	37.26	42.88	15.03	5.38	5.87	5.24	3.69	9.02	23.93	26.35	10.06
4.1	3.20	10.82	3.88	52.09	69.38	12.47	37.54	43.35	14.70	5.61	6.24	5.46	3.74	8.73	24.59	27.46	10.05
4.3	3.18	11.20	4.40	56.30	76.15	12.04	37.76	43.84	14.44	5.82	6.67	5.74	3.84	8.42	25.15	28.55	10.05
4.5	3.15	11.53	4.94	60.55	83.08	11.58	37.93	44.33	14.22	6.03	7.16	6.11	3.97	8.11	25.68	29.49	9.95
4.7	3.11	11.81	5.49	64.84	90.15	11.15	38.02	44.81	14.09	6.29	7.76	6.60	4.15	7.80	26.05	30.39	9.86
4.9	3.07	12.06	6.06	69.15	97.36	10.67	38.04	45.32	14.03	6.20	8.41	7.17	4.37	7.47	26.37	31.17	9.82
5.1	3.02	12.25	6.64	73.48	104.71	10.27	38.00	45.75	14.05	5.98	9.11	7.82	4.66	7.19	26.60	31.92	9.84
5.3	2.97	12.40	7.22	77.81	112.22	9.87	37.92	46.17	14.11	5.76	9.85	8.54	5.05	6.91	26.54	32.32	9.88
5.5	2.90	12.50	7.80	82.14	119.88	9.52	37.68	46.53	14.33	5.56	10.68	9.42	5.54	6.66	26.38	32.57	10.03
5.7	2.83	12.56	8.37	86.46	127.70	9.13	37.39	46.92	14.62	5.33	11.51	10.44	6.12	6.39	26.17	32.85	10.24
5.9	2.76	12.57	8.92	90.78	135.71	8.70	37.05	47.36	14.95	5.08	12.37	11.56	6.99	6.09	25.94	33.15	10.47
6.1	2.67	12.54	9.47	95.11	143.91	8.20	36.65	47.86	15.35	4.79	13.39	12.85	7.98	5.79	25.65	33.51	10.75
6.3	2.58	12.48	9.99	99.48	152.31	7.63	36.18	48.45	15.81	4.45	14.37	14.32	9.17	5.34	25.33	33.91	11.06
6.5	2.48	12.38	10.48	103.91	160.91	7.00	35.66	49.09	16.32	4.09	15.44	15.89	9.51	4.90	24.96	34.36	11.43
6.7	2.37	12.24	10.95	108.39	169.71	6.46	35.24	49.63	16.74	3.77	16.81	17.72	9.78	4.52	24.66	34.74	11.72
6.9	2.25	12.08	11.38	112.93	178.73	5.84	34.77	50.27	17.19	3.41	17.99	19.68	10.04	4.08	24.34	35.19	12.03
7.1	2.11	11.90	11.77	117.55	188.04	5.23	34.29	50.88	17.66	3.05	19.08	21.79	10.31	3.65	24.01	35.62	12.36
7.3	1.96	11.69	12.13	122.24	197.68	4.62	33.80	51.50	18.15	2.70	19.62	24.44	10.60	2.74	23.66	36.05	12.70
7.5	1.80	11.48	12.44	127.03	207.70	4.03	33.15	52.08	18.80	2.35	19.27	26.97	10.98	0.31	23.20	36.46	13.16
7.7	1.63	11.26	12.70	131.93	218.07	3.61	32.21	52.46	19.78	2.11	18.75	29.51	11.55	2.03	22.55	36.73	13.85
7.9	1.44	11.05	12.92	136.97	228.70	3.18	31.25	52.85	20.78	1.86	18.21	30.70	12.14	2.20	21.87	37.00	14.56
8.1	1.23	10.85	13.10	142.00	239.43	2.98	30.99	53.05	21.04	1.74	18.06	30.88	12.29	2.09	20.78	37.14	14.73
8.3	1.01	10.66	13.23	146.76	250.19	3.05	30.78	52.97	21.27	1.78	17.94	30.87	12.42	2.13	11.67	37.08	14.89
8.5	0.79	10.51	13.32	151.46	260.85	3.99	28.75	51.82	23.51	2.33	16.74	30.22	13.73	2.79	12.47	36.27	16.46
8.7	0.59	10.39	13.38	157.76	271.00	6.41	23.37	48.84	29.44	3.74	13.61	28.50	17.20	4.48	13.86	34.19	20.61
8.9	0.40	10.29	13.41	166.32	279.95	6.23	23.07	49.01	29.76	3.64	13.44	28.62	17.38	4.36	14.49	34.31	20.83
9.1	0.20	10.23	13.42	177.73	287.16	6.25	22.98	48.98	29.86	3.65	13.40	28.61	17.44	4.37	14.84	34.29	20.90
9.3	-0.00	10.21	13.42	200.17	292.46	6.27	22.90	48.95	29.94	3.66	13.38	28.59	17.48	4.39	15.55	34.26	20.96
9.5	-0.07	10.22	13.42	-555.01	297.41	22.77	12.07	30.50	42.73	13.30	7.02	17.81	24.95	15.94	8.16	21.35	29.91
9.7	-0.05	10.23	13.41	-1364.22	304.96	22.53	15.17	30.98	39.39	13.15	7.83	18.00	23.00	15.77	10.10	21.69	27.87
9.9	-0.10	10.22	13.40	-1374.76	316.44	22.10	16.12	31.51	38.34	12.90	6.67	16.38	22.39	15.47	10.67	22.06	26.84
10.1	-0.16	10.22	13.38	-1327.05	331.69	22.61	16.66	31.00	37.80	13.19	8.39	13.02	22.08	15.83	10.90	21.70	26.46

TABLE 13. FRONT-WHEEL STEERING FAILURE ON 15 DEG SIDE SLOPE (DRIVING AT 400 W)

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	2.22	0.00	0.00	0.00	0.00	24.00	24.00	31.00	31.00	7.15	7.15	9.23	9.23	0.00	0.00	0.00	0.00
0.1	2.27	0.22	0.00	1.09	0.00	19.58	19.58	33.06	33.06	5.69	5.69	9.61	9.61	1.31	1.31	2.21	2.21
0.3	2.37	0.69	0.02	2.97	0.02	21.16	18.66	31.31	34.16	5.87	5.16	8.67	9.48	3.57	3.14	5.06	5.54
0.5	2.46	1.17	0.05	4.09	0.08	23.20	17.05	29.00	36.03	6.14	4.48	7.63	9.56	3.46	2.65	5.88	7.34
0.7	2.54	1.67	0.09	4.69	0.23	23.69	16.93	28.47	36.20	6.00	4.21	7.12	9.21	0.02	0.28	6.03	7.75
0.9	2.63	2.18	0.13	5.38	0.60	22.87	18.19	29.44	34.79	5.60	4.25	6.94	8.58	3.04	0.67	5.79	7.03
1.1	2.71	2.71	0.19	6.41	1.42	22.19	19.40	30.25	33.44	5.33	4.19	6.62	8.10	4.63	1.59	4.65	5.42
1.3	2.79	3.26	0.26	7.76	2.90	21.48	20.68	31.10	32.02	5.08	4.07	6.24	7.67	6.05	2.50	2.39	2.74
1.5	2.87	3.82	0.34	9.49	5.11	20.47	22.33	32.30	30.18	4.79	4.02	5.94	7.15	7.36	3.64	0.75	0.81
1.7	2.94	4.39	0.45	11.69	7.99	19.19	24.32	33.82	27.96	4.46	4.02	5.73	6.52	8.34	5.07	4.00	3.79
1.9	3.01	4.97	0.58	14.37	11.44	18.03	26.21	35.20	25.84	4.18	4.01	5.51	6.92	9.11	6.69	6.36	5.50
2.1	3.08	5.55	0.75	17.42	15.36	17.28	27.71	36.10	24.18	4.03	3.93	5.22	5.43	9.66	8.55	8.56	6.85
2.3	3.14	6.14	0.95	20.75	19.70	16.64	29.11	36.89	22.64	3.94	3.86	4.92	4.98	10.06	10.52	10.84	7.80
2.5	3.20	6.73	1.19	24.30	24.43	16.05	30.45	37.62	21.17	3.91	3.84	4.70	4.57	10.28	12.44	12.95	8.58
2.7	3.26	7.31	1.48	28.04	29.53	15.55	31.61	38.24	19.88	3.95	3.82	4.48	4.22	10.40	14.42	14.95	9.15
2.9	3.31	7.88	1.81	31.92	34.97	15.10	32.71	38.81	18.67	4.06	3.84	4.27	3.91	10.40	16.37	16.91	9.49
3.1	3.36	8.43	2.18	35.91	40.72	14.68	33.72	39.32	17.56	4.25	3.90	4.10	3.64	10.28	18.09	18.87	9.59
3.3	3.40	8.96	2.60	39.97	46.77	14.32	34.58	39.77	16.61	4.50	4.02	3.95	3.43	10.03	19.81	20.56	9.67
3.5	3.43	9.47	3.05	44.08	53.06	13.99	35.35	40.18	15.76	4.86	4.21	3.86	3.26	9.79	21.33	21.98	9.68
3.7	3.46	9.95	3.55	48.20	59.59	13.69	36.01	40.55	15.03	5.02	4.40	3.83	3.14	9.58	22.43	23.44	9.61
3.9	3.48	10.39	4.08	52.31	66.33	13.27	36.48	41.03	14.50	5.16	4.63	3.87	3.09	9.29	23.31	24.81	9.59
4.1	3.50	10.80	4.65	56.40	73.24	12.86	36.84	41.50	14.09	5.33	4.94	3.98	3.08	9.00	24.16	26.09	9.57
4.3	3.51	11.16	5.25	60.46	80.32	12.42	37.15	41.99	13.72	5.65	5.39	4.18	3.11	8.70	24.90	27.26	9.51
4.5	3.81	11.49	5.87	64.46	87.53	11.94	37.39	42.52	13.43	5.99	5.94	4.47	3.19	8.36	25.52	28.31	9.40
4.7	3.50	11.77	6.51	68.42	94.86	11.46	37.54	43.05	13.24	6.35	6.57	4.85	3.32	8.02	26.04	29.29	9.26
4.9	3.49	12.00	7.17	72.31	102.33	10.96	37.62	43.59	13.11	6.37	7.30	5.34	3.52	7.67	26.33	30.17	9.18
5.1	3.47	12.19	7.84	76.12	109.93	10.52	37.59	44.06	13.12	6.14	8.20	5.93	3.81	7.36	26.31	30.84	9.18
5.3	3.44	12.34	8.51	79.82	117.67	10.13	37.43	44.46	13.27	5.92	9.19	6.77	4.19	7.09	26.20	31.13	9.29
5.5	3.40	12.44	9.19	83.42	125.56	9.73	37.14	44.87	13.54	5.68	10.30	7.76	4.74	6.81	26.00	31.41	9.48
5.7	3.36	12.49	9.86	86.89	133.62	9.25	36.79	45.36	13.88	5.40	11.52	8.95	5.43	6.48	25.76	31.75	9.72
5.9	3.30	12.51	10.53	90.26	141.88	8.70	36.38	45.93	14.29	6.08	12.94	10.47	6.39	6.09	25.46	32.15	10.00
6.1	3.24	12.49	11.18	93.54	150.38	8.00	35.85	46.63	14.80	4.67	14.50	12.25	7.75	5.60	25.09	32.64	10.36
6.3	3.17	12.43	11.82	96.76	159.13	7.18	35.20	47.47	15.44	4.19	16.58	14.43	8.98	5.02	24.64	33.23	10.81
6.5	3.09	12.34	12.44	99.94	168.16	6.20	34.46	48.47	16.16	3.62	18.75	17.04	9.44	4.34	24.12	33.93	11.31
6.7	2.99	12.22	13.03	103.08	177.52	5.24	33.75	49.44	16.85	3.06	19.63	20.12	9.84	3.67	23.62	34.61	11.80
6.9	2.88	12.07	13.60	106.13	187.27	4.50	33.07	50.19	17.52	2.63	19.32	24.33	10.23	2.97	23.15	35.13	12.27
7.1	2.75	11.90	14.14	109.03	197.44	3.83	32.29	50.84	18.32	2.24	18.86	29.40	10.70	1.95	22.60	35.59	12.82
7.3	2.60	11.72	14.64	111.73	208.05	3.04	31.29	51.62	19.34	1.78	18.27	30.10	11.29	0.08	21.90	36.13	13.54
7.5	2.44	11.52	15.11	114.08	219.07	2.91	30.71	51.72	19.94	1.70	17.93	30.21	11.65	1.50	21.50	36.20	13.96
7.7	2.26	11.32	15.53	115.80	230.33	2.87	30.33	51.74	20.35	1.68	17.71	30.21	11.88	1.89	21.23	36.22	14.24
7.9	2.07	11.13	15.92	116.62	241.70	2.86	30.22	51.74	20.47	1.67	17.65	30.22	11.95	2.00	21.15	36.22	14.33
8.1	1.86	10.96	16.27	116.19	253.11	2.85	30.18	51.74	20.51	1.67	17.63	30.22	11.98	2.00	16.08	36.22	14.36
8.3	1.68	10.80	16.59	115.74	264.22	6.76	21.90	46.96	29.66	3.95	12.79	27.43	17.32	4.73	15.33	32.87	20.76
8.5	1.52	10.67	16.88	115.11	274.26	6.20	22.04	47.57	29.47	3.62	12.87	27.78	17.21	4.34	15.43	33.30	20.28
8.7	1.36	10.55	17.14	112.72	282.54	6.25	22.04	47.52	29.47	3.65	12.87	27.75	17.21	4.37	15.43	33.27	19.14
8.9	1.20	10.46	17.38	108.43	288.90	6.46	21.83	47.29	29.71	3.77	12.75	27.62	17.35	4.52	15.28	32.51	16.56
9.1	1.06	10.40	17.60	102.22	293.39	7.03	21.25	46.63	30.37	4.10	18.41	27.23	17.74	4.92	14.88	19.32	8.43
9.3	0.94	10.37	17.79	95.58	296.32	10.76	17.50	42.37	34.66	6.28	10.22	24.74	20.24	7.53	12.25	17.77	10.95
9.5	0.82	10.35	17.97	93.08	298.67	20.44	7.71	31.30	45.84	11.93	4.50	18.28	26.77	14.30	5.40	15.47	16.22
9.7	0.67	10.34	18.12	93.59	301.53	20.04	7.81	31.72	45.71	11.71	4.56	18.53	26.69	14.03	5.47	2.30	1.28
9.9	0.54	10.34	18.24	89.80	304.74	15.08	12.81	37.40	40.00	8.80	7.48	21.84	23.36	10.55	8.97	8.52	2.93
10.1	0.42	10.35	18.33	81.69	307.72	16.95	11.09	35.28	41.97	9.90	6.48	20.60	24.61	11.86	7.76	23.95	10.09

TABLE 14. FRONT-WHEEL STEERING FAILURE ON 7.5 DEG DOWNSLOPE (DRIVING AT 400 W)

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	2.22	0.00	0.00	0.00	0.00	24.00	24.00	31.00	31.00	7.15	7.15	9.23	9.23	0.00	0.00	0.00	0.00
0.1	2.29	0.23	0.00	0.00	0.00	20.23	20.23	33.80	33.80	5.82	5.82	9.72	9.72	0.00	0.00	0.00	0.00
0.3	2.43	0.70	0.00	0.00	-0.00	20.49	20.49	33.55	33.55	5.48	5.48	8.97	8.97	0.00	0.00	0.00	0.00
0.5	2.56	1.20	0.00	-0.00	-0.00	20.82	20.82	33.21	33.21	5.18	5.18	8.26	8.26	2.12	1.90	0.00	0.00
0.7	2.69	1.72	0.00	0.14	0.05	20.38	21.91	33.77	32.02	4.78	5.08	7.80	7.47	4.89	4.94	0.25	0.24
0.9	2.81	2.27	0.00	0.64	0.35	19.55	23.49	34.76	30.26	4.38	5.00	7.34	6.70	6.46	6.15	1.28	1.14
1.1	2.92	2.84	0.02	1.48	1.11	19.05	24.77	35.39	28.85	4.13	4.76	6.74	6.13	7.51	7.42	3.28	2.83
1.3	3.02	3.44	0.04	2.61	2.48	18.35	26.29	36.25	27.17	3.89	4.60	6.27	5.58	8.38	8.74	5.56	4.47
1.5	3.12	4.05	0.07	4.05	4.44	17.65	27.79	37.11	25.51	3.70	4.44	5.82	5.07	9.09	10.37	7.87	5.94
1.7	3.21	4.68	0.13	5.78	6.97	16.97	29.29	37.94	23.87	3.56	4.29	5.38	4.60	9.55	11.95	10.33	7.27
1.9	3.29	5.33	0.20	7.76	10.00	16.34	30.69	38.72	22.32	3.48	4.15	5.02	4.20	9.91	13.66	12.78	8.27
2.1	3.36	5.98	0.31	9.97	13.50	15.75	32.00	39.45	20.87	3.47	4.10	4.75	3.86	10.12	15.55	15.11	8.94
2.3	3.41	6.65	0.44	12.38	17.40	15.21	33.20	40.11	19.54	3.53	4.10	4.52	3.57	10.20	17.34	17.29	9.46
2.5	3.46	7.32	0.60	14.94	21.67	14.72	34.28	40.71	18.36	3.66	4.17	4.34	3.33	10.17	19.00	19.45	9.68
2.7	3.50	7.98	0.79	17.63	26.27	14.29	35.22	41.24	17.32	3.88	4.30	4.22	3.15	10.00	20.61	21.29	9.80
2.9	3.52	8.65	1.02	20.42	31.15	13.91	36.01	41.71	16.44	4.17	4.51	4.18	3.03	9.73	22.12	22.83	9.85
3.1	3.53	9.30	1.29	23.29	36.30	13.56	36.67	42.13	15.71	4.55	4.81	4.21	2.96	9.49	23.37	24.39	9.87
3.3	3.53	9.94	1.58	26.20	41.69	13.19	37.26	42.56	15.05	5.04	5.26	4.34	2.95	9.24	24.52	25.77	9.83
3.5	3.52	10.57	1.91	29.17	47.29	12.81	37.76	43.01	14.49	5.65	5.85	4.56	2.98	8.97	25.52	27.06	9.74
3.7	3.49	11.17	2.27	32.19	53.09	12.39	38.18	43.49	14.01	5.97	6.39	4.87	3.06	8.67	26.13	28.25	9.63
3.9	3.46	11.75	2.65	35.24	59.10	11.88	38.35	44.04	13.79	6.26	6.99	5.29	3.23	8.32	26.58	29.33	9.65
4.1	3.41	12.30	3.06	38.33	65.31	11.36	38.45	44.62	13.65	6.59	7.71	5.81	3.44	7.95	26.91	30.35	9.55
4.3	3.35	12.81	3.50	41.46	71.71	10.81	38.45	45.19	13.61	6.30	8.54	6.50	3.74	7.57	26.92	31.26	9.52
4.5	3.28	13.30	3.95	44.61	78.30	10.40	38.30	45.63	13.74	6.07	9.41	7.33	4.13	7.28	26.81	31.94	9.62
4.7	3.21	13.75	4.42	47.77	85.08	9.95	38.08	46.09	13.94	5.81	10.39	8.28	4.59	6.97	26.66	32.26	9.76
4.9	3.12	14.16	4.90	50.93	92.06	9.53	37.77	46.53	14.25	5.56	11.42	9.41	5.24	6.67	26.44	32.57	9.97
5.1	3.02	14.54	5.38	54.11	99.26	9.03	37.39	47.03	14.62	5.27	12.48	10.75	5.98	6.32	26.17	32.92	10.23
5.3	2.92	14.87	5.87	57.32	106.69	8.47	36.95	47.60	15.05	4.95	13.72	12.21	7.06	5.93	25.86	33.32	10.53
5.5	2.80	15.17	6.36	60.59	114.38	7.81	36.42	48.27	15.56	4.56	14.90	13.96	8.35	5.46	25.50	33.79	10.89
5.7	2.68	15.42	6.85	63.94	122.33	7.08	35.82	49.01	16.16	4.13	16.41	15.83	9.40	4.95	25.07	34.31	11.31
5.9	2.54	15.64	7.32	67.42	130.55	6.29	35.20	49.81	16.76	3.67	17.90	18.07	9.79	4.40	24.64	34.87	11.73
6.1	2.39	15.81	7.78	71.01	139.06	5.55	34.63	50.56	17.33	3.24	19.32	20.38	10.12	3.89	24.24	35.39	12.13
6.3	2.22	15.95	8.22	74.74	147.92	4.83	34.06	51.30	17.89	2.82	19.78	23.21	10.45	3.35	23.84	35.91	12.52
6.5	2.04	16.05	8.64	78.57	157.16	4.23	33.47	51.90	18.47	2.47	19.49	26.20	10.79	2.47	23.43	36.33	12.93
6.7	1.84	16.11	9.02	82.49	166.82	3.75	32.83	52.36	19.13	2.19	19.14	29.10	11.17	0.18	22.98	36.65	13.39
6.9	1.63	16.14	9.37	86.52	176.85	3.27	31.85	52.80	20.14	1.91	18.59	30.68	11.76	1.88	22.30	36.96	14.10
7.1	1.40	16.15	9.67	90.63	187.15	3.00	31.10	53.05	20.92	1.75	18.16	30.89	12.22	2.09	21.77	37.13	14.64
7.3	1.16	16.14	9.93	94.57	197.58	2.95	30.99	53.09	21.04	1.72	18.09	30.97	12.29	2.06	19.78	37.16	14.73
7.5	0.90	16.12	10.13	98.10	208.01	3.14	30.55	52.86	21.52	1.83	17.82	30.85	12.57	2.20	6.63	37.00	15.06
7.7	0.66	16.09	10.28	102.55	218.18	5.89	24.67	49.49	28.02	3.44	14.37	28.90	16.36	4.12	14.70	34.64	19.61
7.9	0.43	16.07	10.39	109.17	227.42	6.39	22.87	48.82	29.99	3.73	13.32	28.51	17.51	4.47	14.79	34.17	20.99
8.1	0.20	16.04	10.44	118.19	235.05	6.27	22.90	48.95	29.94	3.66	13.35	28.59	17.49	4.39	15.16	34.27	20.96
8.3	-0.04	16.04	10.46	136.04	240.79	6.30	22.83	48.91	30.02	3.68	13.32	28.56	17.53	4.41	15.60	34.24	21.01
8.5	-0.15	16.03	10.44	51.60	246.14	22.77	12.08	30.50	42.72	13.30	7.02	17.77	24.95	15.94	7.35	21.35	29.70
8.7	-0.20	16.01	10.45	-44.93	254.11	22.62	15.00	30.87	39.58	13.21	8.25	17.97	23.11	15.83	10.06	21.61	27.71
8.9	-0.23	15.97	10.47	-29.99	265.97	22.00	16.08	31.61	38.38	12.85	7.12	17.28	22.41	15.40	10.76	22.13	26.87
9.1	-0.19	15.93	10.48	-2.92	281.63	22.40	16.47	31.21	37.99	13.08	5.73	14.21	22.19	15.68	10.99	21.85	26.59
9.3	-0.16	15.90	10.48	25.84	301.05	23.02	17.29	30.61	37.15	13.42	4.79	11.82	21.67	16.11	11.55	21.43	26.00
9.5	-0.15	15.88	10.46	61.79	324.07	23.33	18.22	30.33	36.18	13.57	3.95	10.03	21.13	16.33	12.17	21.23	25.33
9.7	-0.16	15.87	10.43	102.96	350.58	23.62	18.79	30.08	35.38	13.70	3.12	8.66	20.66	16.53	12.65	21.06	24.76
9.9	-0.21	15.89	10.40	140.68	380.47	23.88	19.63	29.85	34.71	13.02	2.36	7.19	20.27	16.71	13.01	20.90	24.29
10.1	-0.29	15.94	10.38	165.37	413.67	24.31	20.16	29.42	34.17	12.99	1.78	6.07	19.96	17.02	13.30	20.60	23.92

TABLE 15. FRONT-WHEEL STEERING FAILURE ON 15 DEG DOWNSLOPE (DRIVING AT 400 W)

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	2.22	0.00	0.00	0.00	0.00	24.00	24.00	31.00	31.00	7.15	7.15	9.23	9.23	0.00	0.00	0.00	0.00
0.1	2.31	0.23	0.00	0.00	0.00	19.58	19.58	33.06	33.06	5.57	5.57	9.41	9.41	0.00	0.00	0.00	0.00
0.3	2.49	0.71	0.00	0.00	0.00	20.01	20.01	32.63	32.63	5.17	5.17	8.43	8.43	0.00	0.00	0.00	0.00
0.5	2.66	1.22	0.00	0.00	0.00	20.43	20.43	32.22	32.22	4.82	4.82	7.59	7.59	2.08	1.87	0.00	0.00
0.7	2.82	1.77	0.00	0.14	0.05	20.06	21.55	32.69	30.98	4.34	4.62	6.97	6.67	4.83	4.88	0.22	0.21
0.9	2.98	2.35	0.00	0.60	0.34	19.33	23.19	33.59	29.18	3.90	4.42	6.35	5.80	6.46	6.18	1.17	1.04
1.1	3.13	2.96	0.02	1.38	1.09	18.91	24.52	34.14	27.72	3.60	4.15	5.71	5.16	7.60	7.55	3.03	2.60
1.3	3.26	3.60	0.04	2.40	2.45	18.27	26.04	34.93	26.04	3.35	3.87	5.10	4.59	8.57	9.03	5.29	4.20
1.5	3.39	4.26	0.07	3.70	4.41	17.59	27.62	35.76	24.31	3.14	3.61	4.56	4.06	9.25	10.77	7.65	5.66
1.7	3.51	4.95	0.13	5.25	6.95	16.94	29.15	36.57	22.62	3.00	3.42	4.10	3.59	9.78	12.57	10.22	6.99
1.9	3.62	5.66	0.20	7.01	10.01	16.28	30.63	37.39	20.98	2.92	3.26	3.69	3.18	10.12	14.54	12.80	7.95
2.1	3.71	6.39	0.30	8.96	13.55	15.66	32.02	38.15	19.45	2.91	3.14	3.31	2.82	10.27	16.49	15.22	8.59
2.3	3.80	7.13	0.43	11.06	17.50	15.14	33.25	38.79	18.10	3.01	3.09	3.08	2.54	10.32	18.30	17.57	9.04
2.5	3.87	7.88	0.60	13.27	21.82	14.66	34.33	39.39	16.90	3.21	3.12	2.90	2.32	10.26	20.11	19.73	9.19
2.7	3.93	8.63	0.79	15.56	26.45	14.22	35.27	39.93	15.86	3.50	3.26	2.78	2.16	9.95	21.81	21.51	9.26
2.9	3.98	9.39	1.02	17.88	31.36	13.84	36.02	40.39	15.03	3.90	3.51	2.73	2.07	9.69	23.18	23.24	9.31
3.1	4.01	10.14	1.28	20.22	36.52	13.44	36.67	40.86	14.31	4.39	3.90	2.77	2.04	9.41	24.40	24.73	9.24
3.3	4.03	10.89	1.57	22.57	41.88	13.07	37.20	41.30	13.72	5.06	4.43	2.89	2.05	9.15	25.41	26.09	9.16
3.5	4.03	11.63	1.90	24.90	47.43	12.65	37.64	41.78	13.21	5.96	5.10	3.11	2.11	8.86	26.27	27.33	9.05
3.7	4.02	12.35	2.25	27.22	53.15	12.17	38.01	42.32	12.78	6.44	5.85	3.43	2.22	8.52	26.61	28.46	8.95
3.9	4.00	13.06	2.63	29.51	59.06	11.62	38.10	42.92	12.65	6.75	6.68	3.90	2.41	8.13	26.67	29.46	8.86
4.1	3.97	13.74	3.04	31.78	65.15	11.10	38.04	43.47	12.68	6.48	7.65	4.57	2.72	7.77	24.62	30.42	8.88
4.3	3.92	14.41	3.47	33.99	71.42	10.64	37.88	43.95	12.81	6.21	8.82	5.38	3.11	7.45	26.52	30.77	8.97
4.5	3.87	15.04	3.91	36.14	77.88	10.20	37.59	44.40	13.10	5.96	10.09	6.41	3.63	7.14	26.31	31.08	9.17
4.7	3.80	15.65	4.38	38.22	84.55	9.69	37.22	44.92	13.45	5.66	11.53	7.72	4.27	6.78	26.06	31.44	9.41
4.9	3.73	16.24	4.85	40.25	91.46	9.08	36.78	45.55	13.88	5.30	13.16	9.32	5.13	6.35	25.75	31.88	9.72
5.1	3.64	16.79	5.34	42.24	98.66	8.34	36.24	46.30	14.41	4.87	14.95	11.28	6.29	5.84	25.36	32.41	10.09
5.3	3.54	17.32	5.83	44.20	106.19	7.47	35.57	47.18	15.06	4.36	17.47	13.64	8.01	5.23	24.90	33.03	10.54
5.5	3.44	17.81	6.32	46.19	114.08	6.29	34.69	48.38	15.92	3.67	20.12	16.48	9.27	4.40	24.28	33.87	11.14
5.7	3.32	18.27	6.82	48.24	122.39	5.08	33.77	49.62	16.82	2.97	19.70	19.98	9.82	3.55	23.64	34.73	11.77
5.9	3.18	18.69	7.31	50.25	131.15	4.51	33.08	50.17	17.51	2.63	19.32	24.55	10.23	3.10	23.16	35.12	12.26
6.1	3.03	19.08	7.80	52.12	140.35	3.80	32.28	50.88	18.32	2.22	18.85	29.54	10.70	2.28	22.60	35.62	12.83
6.3	2.85	19.43	8.26	53.84	150.00	3.03	31.34	51.64	19.27	1.77	18.30	30.16	11.26	0.98	21.94	36.15	13.49
6.5	2.66	19.76	8.71	55.22	160.09	2.91	30.95	51.73	19.69	1.70	18.08	30.21	11.50	0.98	21.67	36.21	13.78
6.7	2.45	20.04	9.13	56.02	170.49	2.88	30.47	51.74	20.20	1.68	17.80	30.21	11.80	1.74	21.33	36.22	14.14
6.9	2.23	20.30	9.52	55.98	181.05	2.86	30.26	51.74	20.42	1.67	17.67	30.22	11.93	1.97	21.10	36.22	14.30
7.1	2.00	20.54	9.87	54.78	191.66	2.86	30.17	51.73	20.52	1.67	17.62	30.21	11.98	2.00	3.22	36.21	14.36
7.3	1.78	20.77	10.17	52.97	202.09	5.41	24.76	48.62	26.50	3.16	14.46	28.39	15.48	3.79	17.33	34.03	18.55
7.5	1.58	20.97	10.44	50.96	211.70	6.58	21.60	47.14	29.96	3.84	12.62	27.53	17.50	4.61	15.12	33.00	20.44
7.7	1.39	21.17	10.67	47.57	219.76	6.24	22.05	47.54	29.46	3.64	12.88	27.76	17.21	4.36	15.43	33.28	18.66
7.9	1.22	21.35	10.85	41.99	225.94	6.54	21.75	47.19	29.81	3.82	12.70	27.56	17.41	4.58	15.22	30.97	15.23
8.1	1.07	21.53	10.99	34.37	230.29	7.53	20.75	46.06	30.95	4.40	12.12	26.90	18.07	5.27	14.52	6.29	2.52
8.3	0.94	21.70	11.10	27.26	233.33	14.08	14.17	38.57	38.46	8.22	8.28	22.53	22.46	9.85	9.92	20.38	15.35
8.5	0.79	21.86	11.17	23.87	236.22	21.37	6.68	30.23	47.01	12.48	3.90	17.65	27.46	14.96	4.67	16.98	17.16
8.7	0.63	21.99	11.23	21.34	239.80	20.39	7.44	31.33	46.12	11.91	4.35	18.30	26.94	14.27	5.21	9.01	3.48
8.9	0.49	22.09	11.26	13.64	243.84	16.62	11.25	35.63	41.78	9.71	6.57	20.81	24.40	11.64	7.88	0.18	0.00
9.1	0.40	22.18	11.27	-2.14	247.66	14.73	13.26	37.80	39.49	8.60	7.74	22.08	23.06	10.31	9.28	21.49	11.99
9.3	0.33	22.25	11.26	-22.94	251.36	20.89	7.15	30.77	46.48	12.20	4.17	17.97	27.14	14.63	5.00	8.17	14.06
9.5	0.35	22.31	11.22	-48.83	254.96	10.42	17.43	42.72	34.72	6.09	10.14	24.95	20.27	7.30	11.91	6.27	18.82
9.7	0.54	22.35	11.14	-70.21	257.60	10.87	17.36	42.24	34.82	6.34	10.09	24.62	20.33	3.33	9.48	18.31	20.82
9.9	0.71	22.38	11.02	-83.26	259.72	22.05	7.46	29.55	46.23	12.84	4.13	17.15	27.00	8.55	1.94	1.19	3.13
10.1	0.86	22.39	10.86	-86.19	262.64	13.51	20.42	39.63	31.73	7.85	8.86	20.36	18.51	4.91	3.39	14.57	17.14

TABLE 16. FRONT-WHEEL STEERING FAILURE WITH COUNTERSTEERING, 400 W, 7.5 DEG SIDE SLOPE

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	2.22	0.00	0.00	0.00	0.00	24.00	24.00	31.00	31.00	7.15	7.15	9.23	9.23	0.00	0.00	0.00	0.00
0.1	2.27	0.22	0.00	0.55	0.00	20.23	20.23	33.80	33.80	5.88	5.88	9.83	9.83	0.68	0.68	1.14	1.14
0.3	2.37	0.69	0.01	1.49	0.01	21.08	19.79	32.86	34.34	5.84	5.47	9.09	9.51	1.96	1.84	2.91	3.04
0.5	2.46	1.17	0.02	2.02	0.04	22.40	18.93	31.39	35.35	5.90	4.97	8.24	9.33	0.60	0.70	3.57	4.03
0.7	2.55	1.67	0.04	2.32	0.15	22.41	19.35	31.41	34.90	5.67	4.82	7.83	8.83	3.14	2.44	3.43	3.85
0.9	2.63	2.19	0.07	2.90	0.52	21.31	21.01	32.70	33.04	5.25	4.92	7.66	8.13	5.05	3.40	2.43	2.54
1.1	2.71	2.72	0.10	3.90	1.39	20.61	22.29	33.54	31.63	5.00	4.82	7.28	7.66	6.33	4.33	0.35	0.35
1.3	2.78	3.27	0.14	5.27	2.91	19.72	23.81	34.61	29.93	4.74	4.74	6.93	7.16	7.36	5.38	2.34	2.26
1.5	2.86	3.83	0.20	7.06	5.05	18.71	25.49	35.80	28.06	4.47	4.71	6.64	6.62	8.20	6.81	4.98	4.34
1.7	2.92	4.40	0.29	9.26	7.74	17.81	27.11	36.88	26.26	4.25	4.68	6.39	6.11	8.93	8.28	7.14	5.81
1.9	2.98	4.98	0.39	11.80	10.94	17.13	28.48	37.71	24.74	4.12	4.62	6.11	5.68	9.42	9.69	9.30	7.11
2.1	3.03	5.57	0.53	14.62	14.59	16.53	29.76	38.45	23.33	4.04	4.56	5.84	5.30	9.81	11.30	11.56	8.14
2.3	3.08	6.15	0.70	17.68	18.66	15.96	31.00	39.15	21.95	4.01	4.53	5.65	4.99	10.06	13.04	15.43	9.84
2.5	3.12	6.74	0.91	21.06	23.09	15.02	32.78	40.29	19.99	3.92	4.63	5.72	4.61	9.90	15.14	20.22	10.88
2.7	3.15	7.32	1.15	24.81	27.72	14.14	34.76	41.37	17.80	3.87	4.87	5.86	4.20	9.63	17.31	22.57	10.72
2.9	3.17	7.88	1.44	28.84	32.41	13.86	35.96	41.75	16.49	3.99	5.08	6.04	4.01	9.68	18.93	24.33	10.55
3.1	3.18	8.42	1.76	33.00	37.10	13.72	36.99	41.98	15.38	4.18	5.31	6.25	3.88	9.60	20.31	25.64	10.24
3.3	3.19	8.95	2.13	37.26	41.78	13.70	37.77	42.06	14.54	4.43	5.55	6.47	3.85	9.59	21.53	26.41	9.96
3.5	3.18	9.44	2.53	41.58	46.44	13.73	38.44	42.07	13.83	4.74	5.79	6.68	3.88	9.61	22.52	26.96	9.67
3.7	3.17	9.90	2.97	45.93	51.10	13.79	38.96	42.04	13.27	4.81	5.94	6.89	3.95	9.65	22.94	27.41	9.29
3.9	3.16	10.32	3.44	50.30	55.78	13.80	39.21	42.05	13.00	4.86	6.05	7.12	4.13	9.66	23.17	27.77	9.10
4.1	3.14	10.70	3.94	54.67	60.49	13.80	39.43	42.07	12.77	4.92	6.17	7.37	4.35	9.66	23.39	28.15	8.94
4.3	3.13	11.04	4.47	59.04	65.23	13.79	39.64	42.09	12.54	4.97	6.29	7.63	4.61	9.65	23.63	28.51	8.78
4.5	3.11	11.34	5.01	63.40	70.01	13.77	39.85	42.13	12.32	5.03	6.43	7.91	4.88	9.64	23.88	28.77	8.62
4.7	3.09	11.60	5.58	67.77	74.81	13.74	40.03	42.17	12.12	5.09	6.58	8.22	5.21	9.62	24.12	29.04	8.49
4.9	3.07	11.81	6.15	72.12	79.64	13.69	40.22	42.24	11.92	5.15	6.73	8.59	5.66	9.58	24.38	29.34	8.34
5.1	3.05	11.98	6.74	76.48	84.49	13.60	40.40	42.35	11.71	5.20	6.91	8.99	6.11	9.52	24.65	29.64	8.20
5.3	3.02	12.10	7.34	80.85	89.35	13.50	40.59	42.47	11.50	5.24	7.10	9.42	6.64	9.45	24.93	29.73	8.05
5.5	2.99	12.17	7.93	85.21	94.21	13.40	40.74	42.59	11.33	5.29	7.30	9.65	6.68	9.38	25.19	29.81	7.93
5.7	2.96	12.20	8.53	89.58	99.09	13.28	40.75	42.72	11.32	5.33	7.47	9.90	6.57	9.30	25.32	29.90	7.93
5.9	2.94	12.18	9.12	93.93	103.97	13.16	40.75	42.85	11.31	5.37	7.64	10.14	6.57	9.21	25.44	29.99	7.92
6.1	2.91	12.12	9.70	98.28	108.89	13.04	40.74	42.97	11.31	5.41	7.82	10.40	6.58	9.13	25.65	30.08	7.92
6.3	2.87	12.01	10.27	102.61	113.84	12.92	40.74	43.10	11.31	5.47	8.03	10.67	6.58	9.04	25.66	30.17	7.91
6.5	2.84	11.87	10.82	106.94	118.83	12.78	40.73	43.25	11.30	5.55	8.25	10.96	6.58	8.95	25.78	30.28	7.91
6.7	2.80	11.68	11.35	111.26	123.87	12.63	40.73	43.41	11.30	5.63	8.47	11.28	6.59	8.84	25.91	30.39	7.91
6.9	2.77	11.46	11.86	115.59	128.98	12.47	40.72	43.58	11.29	5.71	8.71	11.65	6.59	8.73	26.04	30.51	7.91
7.1	2.73	11.20	12.35	119.93	134.16	12.30	40.71	43.77	11.29	5.79	8.97	12.04	6.60	8.61	26.17	30.64	7.91
7.3	2.68	10.92	12.81	124.28	139.42	12.11	40.70	43.96	11.29	5.87	9.23	12.46	6.60	8.48	26.30	30.77	7.91
7.5	2.64	10.60	13.23	128.65	144.78	11.92	40.68	44.17	11.30	5.95	9.52	12.92	6.60	8.34	26.43	30.92	7.91
7.7	2.59	10.26	13.63	133.05	150.25	11.72	40.66	44.39	11.30	6.03	9.82	13.41	6.60	8.20	26.55	31.07	7.91
7.9	2.53	9.90	13.99	137.50	155.84	11.50	40.64	44.61	11.31	6.10	10.14	13.94	6.61	8.05	26.64	31.23	7.92
8.1	2.47	9.52	14.31	141.99	161.56	11.28	40.60	44.85	11.33	6.18	10.49	14.50	6.62	7.89	26.72	31.40	7.93
8.3	2.40	9.12	14.60	146.55	167.43	11.04	40.56	45.10	11.36	6.31	10.88	15.16	6.63	7.73	26.79	31.57	7.95
8.5	2.33	8.72	14.84	151.19	173.45	10.76	40.51	45.40	11.39	6.24	11.29	15.94	6.65	7.53	26.84	31.78	7.97
8.7	2.26	8.31	15.05	155.93	179.65	10.49	40.44	45.68	11.45	6.10	11.72	16.75	6.69	7.34	26.85	31.98	8.01
8.9	2.17	7.90	15.21	160.79	186.04	10.24	40.36	45.95	11.52	5.96	12.15	17.60	6.73	7.17	26.84	32.16	8.06
9.1	2.08	7.49	15.33	165.79	192.62	9.97	40.27	46.22	11.69	5.81	12.60	18.48	6.77	6.98	26.78	32.36	8.11
9.3	1.98	7.09	15.41	170.96	199.41	9.70	40.17	46.51	11.68	5.66	13.04	19.40	6.82	6.79	26.66	32.55	8.18
9.5	1.88	6.71	15.46	176.33	206.43	9.43	40.06	46.79	11.78	5.51	13.54	20.69	6.88	6.60	26.48	32.75	8.26
9.7	1.77	6.34	15.46	181.98	213.67	9.08	39.90	47.16	11.93	5.30	14.05	22.03	6.96	6.36	26.17	33.01	8.35
9.9	1.66	6.00	15.43	187.97	221.16	8.72	39.72	47.53	12.10	5.09	14.52	23.35	7.06	6.11	25.69	33.27	8.47
10.1	1.52	5.69	15.37	194.40	228.90	8.40	39.51	47.86	12.30	4.90	14.94	24.62	7.18	5.88	24.96	33.50	8.61
10.3	1.39	5.42	15.29	201.36	236.88	8.11	39.26	48.15	12.55	4.74	16.29	26.70	7.33	5.68	23.86	33.70	8.79

TABLE 17. FRONT-WHEEL STEERING FAILURE WITH COUNTERSTEERING, 400 W, 15 DEG SIDE SLOPE

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	2.22	0.00	0.00	0.00	0.00	24.00	24.00	31.00	31.00	7.15	7.15	9.23	9.23	0.00	0.00	0.00	0.00
0.1	2.27	0.22	0.00	1.09	0.00	19.58	19.58	33.06	33.06	5.69	5.69	9.61	9.61	1.31	1.31	2.21	2.21
0.3	2.37	0.69	0.02	2.97	0.02	21.16	18.66	31.31	34.16	5.87	5.16	8.67	9.48	3.57	3.14	5.06	5.54
0.5	2.46	1.17	0.05	4.09	0.08	23.20	17.05	29.00	36.03	6.14	4.48	7.63	9.56	3.46	2.65	5.88	7.34
0.7	2.54	1.67	0.09	4.69	0.23	23.69	16.93	28.47	36.20	6.00	4.21	7.12	9.21	0.02	0.28	6.03	7.75
0.9	2.63	2.18	0.13	5.38	0.60	22.87	18.19	29.44	34.79	5.60	4.25	6.94	8.58	3.04	0.67	5.79	7.03
1.1	2.71	2.71	0.19	6.41	1.42	22.19	19.40	30.25	33.44	5.33	4.19	6.62	8.10	4.63	1.59	4.65	5.42
1.3	2.79	3.26	0.26	7.76	2.90	21.48	20.68	31.10	32.02	5.08	4.07	6.24	7.67	6.05	2.50	2.39	2.74
1.5	2.87	3.82	0.34	9.49	5.11	20.47	22.33	32.30	30.18	4.79	4.02	5.94	7.15	7.36	3.64	0.75	0.81
1.7	2.94	4.39	0.45	11.69	7.99	19.19	24.32	33.82	27.96	4.46	4.02	5.73	6.52	8.34	5.07	4.00	3.79
1.9	3.01	4.97	0.58	14.37	11.44	18.03	26.21	35.20	25.84	4.18	4.01	5.51	5.92	9.11	6.69	6.36	5.50
2.1	3.08	5.55	0.75	17.42	15.36	17.28	27.71	36.10	24.18	4.03	3.93	5.22	5.43	9.66	8.55	8.56	6.86
2.3	3.14	6.14	0.95	20.75	19.70	16.64	29.11	36.89	22.64	3.94	3.86	4.97	5.01	10.06	10.52	12.79	9.02
2.5	3.20	6.73	1.20	24.39	24.39	15.53	31.12	38.23	20.40	3.78	3.94	4.97	4.53	9.95	12.71	17.94	10.52
2.7	3.26	7.31	1.48	28.43	29.30	14.53	33.28	39.46	18.03	3.66	4.11	5.03	4.02	9.72	15.11	20.56	10.44
2.9	3.30	7.87	1.82	32.71	34.24	14.21	34.61	39.89	16.57	3.73	4.23	5.08	3.75	9.78	17.06	22.32	10.32
3.1	3.34	8.41	2.20	37.10	39.17	14.07	35.73	40.12	15.36	3.89	4.35	5.14	3.55	9.85	18.66	23.59	10.03
3.3	3.37	8.93	2.62	41.52	44.07	14.08	36.61	40.18	14.42	4.12	4.47	5.21	3.45	9.85	19.95	24.54	9.73
3.5	3.40	9.42	3.09	45.93	48.94	14.15	37.32	40.15	13.67	4.40	4.59	5.26	3.41	9.90	21.18	25.16	9.43
3.7	3.42	9.88	3.59	50.30	53.81	14.25	37.92	40.08	13.03	4.46	4.63	5.31	3.42	9.98	21.79	25.60	9.12
3.9	3.44	10.29	4.14	54.61	58.68	14.30	38.24	40.06	12.69	4.51	4.66	5.40	3.55	10.01	22.20	26.09	8.88
4.1	3.46	10.67	4.71	58.83	63.58	14.33	38.52	40.04	12.39	4.56	4.69	5.53	3.71	10.03	22.63	26.50	8.67
4.3	3.47	11.01	5.32	62.96	68.50	14.35	38.78	40.04	12.11	4.63	4.73	5.69	3.90	10.04	23.10	26.91	8.48
4.5	3.49	11.30	5.95	67.01	73.45	14.34	39.05	40.07	11.83	4.71	4.80	5.89	4.15	10.04	23.61	27.27	8.28
4.7	3.50	11.55	6.60	70.97	78.43	14.31	39.29	40.12	11.56	4.80	4.90	6.14	4.46	10.01	24.16	27.61	8.09
4.9	3.51	11.76	7.27	74.84	83.44	14.24	39.54	40.21	11.29	4.92	5.02	6.44	4.81	9.97	24.69	28.00	7.90
5.1	3.51	11.92	7.96	78.63	88.48	14.14	39.78	40.34	11.02	5.04	5.17	6.80	5.35	9.89	25.18	28.24	7.72
5.3	3.52	12.04	8.65	82.35	93.55	13.99	39.99	40.51	10.79	5.17	5.35	7.23	5.96	9.79	25.69	28.36	7.56
5.5	3.51	12.11	9.35	85.99	98.65	13.82	40.17	40.71	10.58	5.30	5.61	7.52	6.14	9.67	26.21	28.50	7.41
5.7	3.50	12.14	10.05	89.55	103.77	13.56	40.23	40.99	10.50	5.41	5.89	7.86	6.10	9.49	26.57	28.69	7.36
5.9	3.49	12.12	10.75	93.04	108.93	13.35	40.26	41.22	10.46	5.56	6.21	8.29	6.09	9.34	26.93	28.85	7.32
6.1	3.48	12.06	11.44	96.45	114.15	13.11	40.29	41.40	10.41	5.80	6.56	8.78	6.07	9.18	27.29	29.04	7.29
6.3	3.45	11.96	12.13	99.78	119.43	12.82	40.31	41.79	10.36	6.05	6.95	9.34	6.05	8.97	27.55	29.25	7.26
6.5	3.43	11.83	12.80	103.05	124.81	12.51	40.31	42.12	10.35	6.30	7.38	9.99	6.04	8.76	27.82	29.48	7.24
6.7	3.39	11.66	13.46	106.26	130.30	12.18	40.30	42.48	10.33	6.55	7.90	10.72	6.03	8.52	28.10	29.73	7.23
6.9	3.35	11.45	14.10	109.40	135.94	11.80	40.28	42.88	10.32	6.85	8.52	11.62	6.03	8.26	28.20	30.01	7.23
7.1	3.31	11.21	14.72	112.49	141.73	11.37	40.21	43.33	10.37	6.62	9.20	12.65	6.06	7.96	28.15	30.33	7.26
7.3	3.25	10.95	15.32	115.52	147.71	11.03	40.07	43.69	10.49	6.44	9.94	13.78	6.13	7.72	28.05	30.58	7.34
7.5	3.19	10.65	15.90	118.48	153.89	10.65	39.93	44.09	10.61	6.22	10.81	15.16	6.20	7.45	27.95	30.86	7.43
7.7	3.12	10.34	16.44	121.36	160.30	10.19	39.76	44.56	10.76	5.95	11.79	16.85	6.29	7.13	27.84	31.20	7.53
7.9	3.03	10.01	16.96	124.19	166.96	9.65	39.56	45.13	10.94	5.64	12.83	18.74	6.39	6.76	27.69	31.59	7.66
8.1	2.94	9.66	17.45	126.97	173.91	9.06	39.34	45.75	11.14	5.29	14.11	21.56	6.50	6.34	27.54	32.02	7.79
8.3	2.84	9.30	17.90	129.71	181.17	8.23	39.03	46.62	11.40	4.80	15.45	24.76	6.66	5.76	27.32	32.63	7.98
8.5	2.72	8.94	18.32	132.45	188.79	7.31	38.69	47.58	11.71	4.27	17.02	27.64	6.84	5.12	27.08	33.30	8.20
8.7	2.59	8.57	18.70	135.17	196.82	6.41	38.35	48.51	12.01	3.75	18.96	28.30	7.01	4.49	26.85	33.96	8.40
8.9	2.44	8.21	19.05	137.78	205.28	5.91	38.15	49.04	12.19	3.45	20.96	28.64	7.12	4.13	26.70	34.33	8.53
9.1	2.28	7.85	19.36	140.15	214.20	5.43	37.97	49.53	12.35	3.17	22.07	28.93	7.21	3.75	26.58	34.67	8.64
9.3	2.09	7.51	19.63	142.14	223.61	5.16	37.84	49.82	12.46	3.01	22.06	29.09	7.28	2.68	26.49	34.87	8.39
9.5	1.89	7.19	19.87	143.52	233.53	5.12	37.55	49.84	12.77	2.99	21.93	29.10	7.46	1.65	26.28	34.89	7.96
9.7	1.68	6.91	20.08	144.13	243.82	5.09	36.43	49.79	13.97	2.97	21.28	29.08	8.16	3.31	25.50	34.86	7.46
9.9	1.46	6.65	20.27	143.67	254.30	5.14	35.83	49.70	14.62	3.00	20.93	29.02	8.54	3.60	25.08	34.79	5.50
10.1	1.24	6.44	20.43	141.58	264.75	5.16	35.26	49.64	15.23	3.01	20.59	28.99	8.90	3.61	5.04	34.75	1.31
10.3	1.05	6.26	20.58	138.98	274.86	8.28	27.62	48.74	23.64	4.84	16.13	26.71	13.81	5.80	19.33	32.02	5.72

TABLE 18. FRONT-WHEEL STEERING FAILURE WITH COUNTERSTEERING, 400 W, 7.5 DEG DOWNSLOPE

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	2.22	0.00	0.00	0.00	0.00	24.00	24.00	31.00	31.00	7.15	7.15	9.23	9.23	0.00	0.00	0.00	0.00
0.1	2.29	0.23	0.00	0.00	0.00	20.23	20.23	33.80	33.80	5.82	5.82	9.72	9.72	0.00	0.00	0.00	0.00
0.3	2.43	0.70	0.00	0.00	-0.00	20.49	20.49	33.55	33.55	5.48	5.48	8.97	8.97	0.00	0.00	0.00	0.00
0.5	2.56	1.20	0.00	-0.00	-0.00	20.82	20.82	33.21	33.21	5.18	5.18	8.26	8.26	2.12	1.90	0.00	0.00
0.7	2.69	1.72	0.00	0.14	0.05	20.38	21.91	33.77	32.02	4.78	5.08	7.80	7.47	4.89	4.94	0.25	0.24
0.9	2.81	2.27	0.00	0.64	0.35	19.55	23.49	34.76	30.26	4.38	5.00	7.34	6.70	6.46	6.15	1.28	1.14
1.1	2.92	2.84	0.02	1.48	1.11	19.05	24.77	35.39	28.85	4.13	4.76	6.74	6.13	7.51	7.42	3.28	2.83
1.3	3.02	3.44	0.04	2.61	2.48	18.35	26.29	36.25	27.17	3.89	4.60	6.27	5.58	8.38	8.74	5.56	4.47
1.5	3.12	4.05	0.07	4.05	4.44	17.65	27.79	37.11	25.51	3.70	4.44	5.82	5.07	9.09	10.37	7.87	5.94
1.7	3.21	4.68	0.13	5.78	6.97	16.97	29.29	37.94	23.87	3.56	4.29	5.38	4.60	9.55	11.95	10.33	7.27
1.9	3.29	5.33	0.20	7.76	10.00	16.34	30.69	38.72	22.32	3.48	4.15	5.02	4.20	9.91	13.66	12.78	8.27
2.1	3.36	5.98	0.31	9.97	13.50	15.75	32.00	39.45	20.87	3.47	4.10	4.75	3.86	10.12	15.55	15.11	8.94
2.3	3.41	6.65	0.44	12.38	17.40	15.21	33.20	40.11	19.54	3.53	4.10	4.59	3.61	10.20	17.34	18.85	10.09
2.5	3.46	7.32	0.60	15.00	21.64	14.40	34.81	41.10	17.76	3.57	4.25	4.70	3.38	9.95	19.30	22.79	10.54
2.7	3.49	7.98	0.80	17.86	26.10	13.79	36.43	41.87	15.98	3.71	4.51	4.88	3.21	9.65	21.32	25.03	10.28
2.9	3.50	8.64	1.03	20.89	30.65	13.51	37.51	42.24	14.81	3.99	4.82	5.18	3.18	9.46	22.96	26.71	10.00
3.1	3.50	9.29	1.30	23.99	35.23	13.33	38.40	42.49	13.84	4.33	5.20	5.54	3.23	9.33	24.31	27.88	9.62
3.3	3.49	9.92	1.60	27.15	39.82	13.23	39.09	42.65	13.10	4.80	5.69	6.03	3.36	9.26	25.45	28.73	9.17
3.5	3.46	10.53	1.93	30.33	44.43	13.13	39.63	42.80	12.61	5.31	6.22	6.57	3.57	9.19	26.33	29.31	8.75
3.7	3.42	11.11	2.29	33.53	49.08	13.02	40.04	42.94	12.07	5.50	6.64	7.15	3.85	9.12	26.88	29.83	8.46
3.9	3.37	11.67	2.69	36.76	53.79	12.80	40.25	43.20	11.82	5.72	7.06	7.82	4.26	8.96	27.26	30.24	8.28
4.1	3.32	12.19	3.10	40.01	58.57	12.54	40.40	43.49	11.64	5.92	7.50	8.59	4.74	8.78	27.54	30.44	8.15
4.3	3.26	12.68	3.54	43.31	63.45	12.27	40.49	43.78	11.53	6.11	7.99	9.49	5.47	8.59	27.78	30.65	8.07
4.5	3.19	13.14	3.99	46.65	68.41	11.91	40.56	44.17	11.42	6.25	8.55	10.45	6.28	8.34	28.01	30.92	7.99
4.7	3.11	13.56	4.46	50.06	73.47	11.50	40.64	44.61	11.31	6.37	9.14	11.50	6.58	8.05	28.24	31.23	7.92
4.9	3.03	13.94	4.94	53.54	78.61	11.19	40.72	44.95	11.20	6.49	9.76	12.67	6.54	7.83	28.47	31.47	7.84
5.1	2.94	14.28	5.44	57.08	83.86	10.94	40.80	45.23	11.10	6.36	10.38	13.87	6.48	7.66	28.56	31.66	7.77
5.3	2.84	14.58	5.93	60.68	89.23	10.76	40.83	45.42	11.05	6.27	11.05	15.10	6.46	7.54	28.58	31.79	7.74
5.5	2.74	14.83	6.42	64.34	94.79	10.57	40.85	45.63	11.02	6.17	11.75	16.22	6.43	7.40	28.59	31.94	7.71
5.7	2.62	15.05	6.92	68.09	100.57	10.20	40.71	46.01	11.14	5.96	12.39	17.44	6.50	7.14	28.50	32.21	7.80
5.9	2.50	15.23	7.40	71.95	106.61	9.83	40.57	46.41	11.26	5.74	13.04	18.71	6.58	6.88	28.40	32.48	7.88
6.1	2.38	15.36	7.87	75.96	112.93	9.44	40.43	46.81	11.39	5.51	13.76	20.23	6.65	6.61	28.30	32.77	7.97
6.3	2.24	15.46	8.32	80.13	119.55	8.99	40.26	47.28	11.54	5.25	14.53	22.12	6.74	6.29	28.18	33.10	8.08
6.5	2.10	15.52	8.75	84.52	126.49	8.45	40.06	47.86	11.72	4.93	15.25	24.06	6.84	5.91	28.04	33.49	8.20
6.7	1.95	15.54	9.15	89.19	133.76	7.91	39.86	48.41	11.89	4.62	15.91	25.98	6.95	5.54	27.90	33.88	8.33
6.9	1.78	15.53	9.52	94.17	141.40	7.39	39.66	48.95	12.07	4.32	16.52	28.28	7.05	5.17	27.76	34.26	8.46
7.1	1.61	15.49	9.86	99.57	149.40	6.81	39.44	49.56	12.26	3.97	17.26	28.80	7.16	4.76	27.40	34.69	8.58
7.3	1.43	15.42	10.16	105.43	157.77	6.59	39.29	49.79	12.41	3.85	17.92	28.98	7.25	4.61	26.67	34.85	8.68
7.5	1.23	15.34	10.41	111.79	166.51	6.48	39.09	49.88	12.61	3.78	18.42	29.08	7.37	4.54	25.17	34.92	8.83
7.7	1.03	15.24	10.61	118.83	175.59	6.49	38.74	49.85	12.98	3.79	18.67	29.09	7.58	4.54	21.77	34.89	8.91
7.9	0.83	15.14	10.77	127.10	184.84	6.66	35.91	49.46	16.04	3.89	17.77	28.89	9.37	4.66	14.41	34.62	10.62
8.1	0.65	15.05	10.88	137.18	193.83	7.27	34.74	48.73	17.33	4.25	17.87	28.46	10.12	5.09	5.00	34.11	11.06
8.3	0.48	14.96	10.95	150.01	202.12	8.12	32.61	47.66	19.68	4.74	17.54	27.83	11.49	5.69	6.23	33.36	12.16
8.5	0.35	14.88	10.98	167.63	209.36	9.15	30.21	46.39	22.32	5.34	17.42	27.09	13.03	6.40	11.05	32.47	13.60
8.7	0.26	14.82	10.98	193.68	215.17	9.44	29.26	46.01	23.35	5.51	17.01	26.87	13.64	6.61	13.43	32.21	14.67
8.9	0.23	14.78	10.96	231.64	219.29	9.67	28.96	45.74	23.70	5.65	16.88	26.71	13.84	6.77	15.90	32.02	16.18
9.1	0.30	14.77	10.91	273.98	221.58	9.94	28.70	45.43	23.99	5.81	16.76	26.53	14.01	6.56	19.40	4.85	5.49
9.3	0.44	14.78	10.84	284.76	222.29	12.96	16.99	41.36	36.76	7.57	9.92	24.16	21.47	6.08	11.89	28.96	16.50
9.5	0.55	14.79	10.74	262.16	222.36	15.40	9.79	38.24	44.64	8.98	5.72	22.32	26.05	6.82	5.52	20.87	21.19
9.7	0.66	14.76	10.62	251.25	222.79	14.20	25.33	40.63	27.91	8.27	14.73	23.65	16.29	7.34	10.01	5.06	18.30
9.9	0.80	14.72	10.48	258.54	223.84	12.21	28.34	42.97	24.54	7.09	16.09	24.95	14.30	2.88	15.11	2.40	14.82
10.1	0.94	14.69	10.31	264.69	225.34	13.64	23.39	41.09	29.94	7.53	12.17	22.85	17.42	0.76	13.77	9.29	15.89
10.3	1.09	14.68	10.10	266.11	227.20	14.63	22.16	39.94	31.34	7.49	10.51	20.54	18.20	0.97	12.98	7.37	16.97

TABLE 19. FRONT-WHEEL STEERING FAILURE WITH COUNTERSTEERING, 400 W, 15 DEG DOWNSLOPE

TIME	V	YM	XM	THETA	OMEGA	A1	A2	A3	A4	B1	B2	B3	B4	S1	S2	S3	S4
0.0	2.22	0.00	0.00	0.00	0.00	24.00	24.00	31.00	31.00	7.15	7.15	9.23	9.23	0.00	0.00	0.00	0.00
0.1	2.31	0.23	0.00	0.00	0.00	19.58	19.58	33.06	33.06	5.57	5.57	9.41	9.41	0.00	0.00	0.00	0.00
0.3	2.49	0.71	0.00	0.00	0.00	20.01	20.01	32.63	32.63	5.17	5.17	8.43	8.43	0.00	0.00	0.00	0.00
0.5	2.66	1.22	0.00	0.00	0.00	20.43	20.43	32.22	32.22	4.82	4.82	7.59	7.59	2.08	1.87	0.00	0.00
0.7	2.82	1.77	0.00	0.14	0.05	20.06	21.55	32.69	30.98	4.34	4.62	6.97	6.67	4.83	4.88	0.22	0.21
0.9	2.98	2.35	0.00	0.60	0.34	19.33	23.19	33.59	29.18	3.90	4.42	6.35	5.80	6.46	6.18	1.17	1.04
1.1	3.13	2.96	0.02	1.38	1.09	18.91	24.52	34.14	27.72	3.60	4.15	5.71	5.16	7.60	7.55	3.03	2.60
1.3	3.26	3.60	0.04	2.40	2.45	18.27	26.04	34.93	26.04	3.35	3.87	5.10	4.59	8.57	9.03	5.29	4.20
1.5	3.39	4.26	0.07	3.70	4.41	17.59	27.62	35.76	24.31	3.14	3.61	4.56	4.06	9.25	10.77	7.65	5.66
1.7	3.51	4.95	0.13	5.25	6.95	16.94	29.15	36.57	22.62	3.00	3.42	4.10	3.59	9.78	12.57	10.22	6.99
1.9	3.62	5.66	0.20	7.01	10.01	16.28	30.63	37.39	20.98	2.92	3.26	3.69	3.18	10.12	14.54	12.80	7.95
2.1	3.71	6.39	0.30	8.96	13.55	15.66	32.02	38.15	19.45	2.91	3.14	3.31	2.82	10.27	16.49	15.22	8.59
2.3	3.80	7.13	0.43	11.06	17.50	15.14	33.25	38.79	18.10	3.01	3.09	3.14	2.59	10.32	18.30	18.92	9.56
2.5	3.87	7.88	0.60	13.32	21.79	14.40	34.79	39.70	16.39	3.15	3.18	3.20	2.43	10.08	20.39	22.72	9.94
2.7	3.92	8.63	0.79	15.73	26.31	13.82	36.37	40.43	14.66	3.38	3.42	3.33	2.32	9.67	22.48	24.93	9.61
2.9	3.96	9.38	1.02	18.23	30.92	13.56	37.38	40.79	13.56	3.76	3.75	3.59	2.35	9.49	24.01	26.49	9.28
3.1	3.98	10.13	1.29	20.73	35.57	13.40	38.18	41.01	12.69	4.25	4.18	4.01	2.46	9.38	25.30	27.58	8.88
3.3	3.98	10.87	1.58	23.22	40.24	13.27	38.79	41.20	12.03	4.88	4.70	4.54	2.68	9.29	26.34	28.34	8.42
3.5	3.97	11.59	1.91	25.67	44.94	13.13	39.25	41.38	11.53	5.63	5.29	5.12	2.98	9.19	27.13	28.97	8.07
3.7	3.95	12.30	2.27	28.07	49.68	12.93	39.62	41.62	11.11	6.06	5.89	5.82	3.38	9.05	27.71	29.14	7.78
3.9	3.91	12.99	2.66	30.44	54.51	12.60	39.72	41.98	10.99	6.45	6.50	6.74	3.95	8.82	27.80	29.39	7.69
4.1	3.87	13.65	3.06	32.78	59.44	12.21	39.72	42.40	10.95	6.85	7.17	7.79	4.72	8.55	27.81	29.68	7.67
4.3	3.82	14.29	3.49	35.09	64.49	11.74	39.72	42.90	10.93	6.82	7.94	9.08	5.83	8.22	27.80	30.03	7.65
4.5	3.76	14.90	3.94	37.39	69.65	11.20	39.67	43.48	10.94	6.53	8.85	10.57	6.37	7.84	27.77	30.43	7.66
4.7	3.69	15.48	4.40	39.66	74.91	10.78	39.62	43.93	10.96	6.29	9.83	12.24	6.40	7.54	27.73	30.75	7.67
4.9	3.61	16.03	4.88	41.90	80.27	10.42	39.57	44.31	10.99	6.08	10.93	14.09	6.42	7.29	27.70	31.01	7.69
5.1	3.52	16.55	5.37	44.09	85.76	10.01	39.50	44.74	11.03	5.84	12.09	16.34	6.44	7.01	27.65	31.32	7.72
5.3	3.42	17.04	5.86	46.25	91.46	9.50	39.41	45.28	11.10	5.55	13.33	18.88	6.48	6.65	27.59	31.69	7.77
5.5	3.31	17.50	6.35	48.38	97.41	8.93	39.30	45.89	11.18	5.21	14.79	21.89	6.53	6.25	27.51	32.12	7.82
5.7	3.19	17.92	6.85	50.51	103.68	8.02	38.96	46.83	11.47	4.68	16.16	25.27	6.70	5.62	27.27	32.78	8.03
5.9	3.05	18.31	7.34	52.68	110.34	7.06	38.60	47.83	11.79	4.12	18.11	27.81	6.88	4.94	27.02	33.48	8.25
6.1	2.91	18.66	7.82	54.88	117.43	6.16	38.26	48.77	12.09	3.60	20.08	28.48	7.06	4.31	26.78	34.14	8.46
6.3	2.75	18.98	8.29	57.01	124.98	5.64	38.05	49.32	12.28	3.30	22.08	28.80	7.17	3.95	26.63	34.52	8.59
6.5	2.57	19.26	8.74	58.97	133.03	5.18	37.87	49.80	12.43	3.02	22.06	29.09	7.26	3.62	26.51	34.86	8.70
6.7	2.37	19.51	9.16	60.58	141.60	5.14	37.84	49.84	12.46	3.00	22.10	29.11	7.28	3.31	26.49	34.89	8.54
6.9	2.16	19.73	9.56	61.64	150.67	5.12	37.73	49.85	12.58	2.99	22.03	29.11	7.35	1.72	26.41	34.90	8.12
7.1	1.93	19.92	9.92	61.96	160.19	5.11	37.26	49.83	13.08	2.98	21.76	29.10	7.64	2.41	26.08	34.88	7.48
7.3	1.70	20.10	10.24	61.40	170.03	5.09	36.12	49.77	14.30	2.98	21.09	29.06	8.35	3.42	25.28	34.84	6.24
7.5	1.47	20.25	10.51	59.59	179.99	5.15	35.50	49.67	14.97	3.00	20.73	29.01	8.74	3.60	24.85	34.77	2.72
7.7	1.25	20.40	10.74	55.96	189.89	5.15	34.58	49.59	15.95	3.01	20.20	28.96	9.32	3.61	24.21	34.72	3.34
7.9	1.07	20.53	10.93	53.10	199.25	10.25	22.33	43.26	29.45	5.98	13.04	25.26	17.20	7.17	15.63	30.28	12.38
8.1	0.92	20.65	11.09	51.11	207.10	9.42	21.63	44.09	30.14	5.50	12.63	25.75	17.60	6.60	15.14	30.86	16.19
8.3	0.76	20.76	11.22	47.10	212.75	9.28	21.11	44.20	30.68	5.42	12.33	25.82	17.92	6.50	14.78	30.77	19.20
8.5	0.61	20.86	11.31	40.50	216.04	9.22	20.53	44.23	31.30	5.39	11.99	25.83	18.28	6.46	14.37	13.34	21.69
8.7	0.46	20.94	11.38	32.60	217.17	10.98	16.22	42.03	36.05	6.41	9.47	24.55	21.05	7.69	10.93	27.21	25.23
8.9	0.28	21.01	11.42	28.46	217.08	14.74	7.31	37.37	45.87	8.61	4.27	21.82	26.79	10.32	4.63	26.16	32.11
9.1	0.08	21.04	11.43	24.99	216.80	13.69	7.69	38.53	45.38	7.99	4.49	22.50	26.50	9.58	4.43	26.97	31.77
9.3	-0.13	21.03	11.43	6.30	216.51	13.78	7.70	38.42	45.38	8.05	4.49	22.44	26.50	9.65	5.39	26.90	31.77
9.5	-0.32	20.99	11.42	13.64	216.12	13.88	7.49	38.31	45.61	8.10	4.37	22.37	26.64	9.71	5.24	26.02	31.93
9.7	-0.50	20.92	11.38	43.26	215.63	13.84	7.51	38.34	45.59	8.09	4.39	22.39	26.62	9.69	4.63	14.13	31.91
9.9	-0.69	20.84	11.29	50.48	214.85	12.45	10.48	40.05	42.31	7.27	6.11	23.33	24.63	8.71	5.54	6.46	28.78
10.1	-0.88	20.74	11.17	52.71	213.22	10.62	15.48	42.48	36.81	6.12	9.02	24.68	19.88	7.36	8.85	22.46	23.76
10.3	-1.05	20.63	11.01	57.02	210.09	9.73	19.19	43.59	32.77	5.65	11.20	25.28	14.03	6.81	11.27	29.04	18.83

APPENDIX

TRACTION FORCES AT VARIOUS ELECTRIC POWER LEVELS AS A FUNCTION OF WHEEL SPEED

Traction forces (or wheel torques) as a function of vehicle speed and power input into the electric drive motor are not available.

For these studies, the traction forces developed by the LRV have been based on a selected electric power level, assumed to remain constant during the time interval for which the LRV motion is to be studied. The traction forces are then derived from general mechanical relations.

I. <u>General Considerations</u>

$$1 \text{ hp} = 76.04 \text{ mkg/s} = 550 \text{ ft-lb/s} = 746 \text{ W} \tag{1}$$

$$(1 \text{ ft-lb/s} = 1.35636 \text{ W}) \tag{2}$$

$$1 \text{ mkg/s} = \frac{746}{76.04} \text{ W} = 9.810 \text{ W}$$

with

R_{eff} effective wheel radius [36.58 cm (1.2 ft = 14.4 in.)]

u $2R\pi \cdot \frac{n}{60}$ = circumferential speed (m/s)

F circumferential force (kg)

W power (W)

n rotational speed of wheel (rpm)

$$\text{Power} = F \cdot R \cdot \frac{2\pi n}{60} \cdot 9.81 \text{ (W)} \tag{3}$$

or the torque

$$F \cdot R = \frac{\text{power (W)}}{n} \cdot 0.9734 \text{ (mkg)} \tag{4}$$

and the tractive force $\boxed{F = \frac{1}{R} \cdot \frac{\text{power (W)}}{n} \cdot 0.9734}$ (kg)

These are the general equations converting the electric power consumed into the circumferential force at the wheel. They do not yet represent the performance of the LRV drive system with its mechanical and electrical losses.

The preliminary LRV Operations Handbook[1] presents the LRV traction drive performance (dc-motor-harmonic drive-drive controller) for full voltage (36 V), and the systems efficiency [based on thermal-vacuum test data with 121° C (250° F) assembly temperature, with voltage applied to the end of 2.44-m (8-ft) pigtails].

Notwithstanding later revised system efficiency data, this information has been used to derive the needed relationship between

ELECTRIC POWER INPUT → MECHANICAL POWER OUTPUT

The data in Table A-1 have been compiled from the handbook.

TABLE A-1. MECHANICAL OUTPUT OF LRV TRACTION DRIVE

Wheel output speed (rpm)	Wheel Torque		η
	mkg	ft-lb	(%)
31	10.77	78.5	39
36	8.09	58.5	47
49	4.56	33	53.5
68	2.35	17	56
91.5	1.18	8.5	52
118	0.52	3.75	43

1. Anon: LRV Operations Handbook. Appendix A, July 17, 1970, p. A8.

Using equation (4), the mechanical power (torque-speed) at the wheel is converted into electrical power in Table A-2. The required power input into the electric drive motor is obtained as a function of the system efficiency, and is given as W_{in} in Table A-2.

TABLE A-2. ELECTRICAL POWER INPUT FOR VARIOUS WHEEL CONDITIONS

Wheel Speed (rpm)	Power at Wheel			Efficiency (%)	Power Input W_{in} (W)
	Torque × rpm		Electrical		
	mkg/min	ft-lb/min	(W)		
31	336	2434	345	39	885
36	292	2106	300	47	638
49	224	1617	230	53.5	430
68	160	1156	164	56	293
91.5	107	778	110	52	212
118	61	442	62.5	43	145

The above is not an indication of the maximum power level available during operation of the LRV. From other sources of information, it appears that maximum electric power input into the drive motor may be as high as 700 W for short periods of time.

However, no information is available at present as to the allowable duration of such a high power consumption. Therefore, it has been assumed for this application that maximum power should not exceed 400 W per wheel.

II. Power Required to Overcome Resistance of Free-Rolling Wheel

According to the Bekker equation, the LRV wheel should have a rolling resistance in lunar soil of 2.72 kg (6 lb). This resistance is independent of vehicle speed. If accumulated soil would be encountered (providing deeper sinkage of the LRV wheel), the resistance may be as high as 4.08 kg (9 lb) per wheel. However, for the purpose of these motion studies, a resistive force of 2.72 kg (6 lb) has been used.

The power required to overcome the free-rolling resistance of the wheel as a function of vehicle speed is shown in Table A-3.

It may be assumed that a certain power setting (at the hand-controller) would remain constant for the time interval of the motion under study and that this power would not change because of the change in drive motor speed under varying load. The latter assumption is, of course, not truly realistic, but it may be considered a second-order effect, compensated by a slight adjustment of the hand-controller setting by the astronaut. The power levels of 200, 300, and 400 W have been used for the purpose of this study.

Table A-4 indicates the free traction force that would be available at the wheel after the power to overcome the rolling resistance has been deducted. Table A-4 gives a summary of the free traction force. Table A-5 summarizes the free traction force and the force coefficient T/W; the latter has been plotted in Figure 2 (page 4).

TABLE A-3. POWER CONSUMPTION CAUSED BY FREE-ROLLING RESISTANCE

Vehicle Speed			Power of Rolling Resistance					
			Mechanical		Electrical		Wheel Speed for R_{eff} = 36.58 cm (1.2 ft)	Power at Drive Motor
m/s	km/hr	ft/s	mkg/s	ft-lb/s	(W)	η (%)	(rpm)[a]	W_{rr} (W)
0	0	0	0	0	0	--	0	0
0.1	0.36	0.328	0.27	1.968	2.67	--	2.61	-
0.5	1.80	1.64	1.36	9.842	13.35	10	13.1	130
1.0	3.6	3.28	2.72	19.685	26.70	25	26.1	107
1.5	5.40	4.92	4.08	29.528	40.05	48.5	39.2	82.5
2.0	7.2	6.56	5.44	39.37	53.40	55	52.2	97
2.5	9.0	8.20	6.80	49.21	66.75	56	65.3	119
3.0	10.8	9.84	8.16	59.06	80.11	55	78.3	145
3.5	12.6	11.48	9.53	68.90	93.46	52	91.4	180
4.0	14.4	13.12	10.89	78.74	106.8	48	104.4	222
4.5	16.2	14.76	12.25	88.58	120.2	44	117.5	272

a. 1 km/hr = 7.2527 rpm for R_{eff} of 36.58 cm (1.2 ft).

TABLE A-4. FREE TRACTION FORCE AT ONE WHEEL

Wheel Speed (rpm)	Vehicle Velocity (m/s)	Power W_{rr} (W)	Power at Drive Motor								
			200 W			300 W			400 W		
			Power at Wheel (W)	T		Power at Wheel (W)	T		Power at Wheel (W)	T	
				kg	lb		kg	lb		kg	lb
0	0	0	200	28.1	62	300	42.2	93	400	>45.4	>100
2.61	0.1	--	15	15.9	35	18	19.1	42	222	34.5	76
13.1	0.5	130	16	4.3	9.5	34	7.3	16	54	11.8	26
26.1	1.0	107	23	2.5	5.44	48	5.2	11.4	73	7.9	17.4
39.2	1.5	82.5	57	4.1	8.98	105	7.5	16.6	154	11.0	24.3
52.2	2.0	97	57	3.1	6.76	112	6.0	13.3	166	9.1	20
65.3	2.5	119	45	1.9	4.26	101	4.3	9.57	157	6.8	15
78.3	3.0	145	30	1.1	2.37	85	3.1	6.72	140	5.0	11
91.4	3.5	180	10	0.3	0.676	62	1.9	4.2	115	3.5	7.8
104.4	4.0	222	-	-	-	37.5	1.0	2.21	85	2.3	5.04
117.5	4.5	272	-	-	-	12.3	0.3	0.65	56	1.3	2.95

TABLE A-5. SUMMARY OF FREE TRACTION FORCES AND T/W VALUES[a]

Vehicle Velocity (m/s)	Power at Drive Motor								
	200 W			300 W			400 W		
	T		T/W	T		T/W	T		T/W
	kg	lb		kg	lb		kg	lb	
0.0	28.1	62	0.400	42.2	93	0.58	> 45.4	> 100	0.58
0.1	16.1	35.5	0.380	19.0	42	0.58	34.5	76	0.58
0.5	4.3	9.45	0.290	7.2	16	0.535	11.6	25.6	0.58
1.0	2.5	5.44	0.215	5.2	11.4	0.380	7.9	17.4	0.545
1.5	4.1	8.98	0.155	7.5	16.6	0.286	11.0	24.3	0.418
2.0	3.1	6.76	0.112	6.0	13.3	0.218	9.0	19.8	0.33
2.5	1.9	4.26	0.0734	4.3	9.57	0.165	6.8	14.9	0.257
3.0	1.1	2.37	0.0408	3.0	6.72	0.116	5.0	11.1	0.191
3.5	0.3	0.68	0.0117	1.9	4.20	0.072	3.5	7.8	0.134
4.0				1.0	2.21	0.038	2.3	5.04	0.087
4.5				0.3	0.65	0.0112	1.3	2.95	0.051

a. T/W values referred to W = 26.31 kg (58 lb) normal wheel load
T/W value at v = 0 cannot exceed maximum traction coefficient of $\mu_T = 0.58$

Values have been smoothed over to fit a continuous trace.

APPROVAL

LRV OPERATIONAL BEHAVIOR STUDY

By Fritz Kramer

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also be reviewed and approved for technical accuracy.

K. L. Heimburg

K. L. HEIMBURG
Director, Astronautics Laboratory

DISTRIBUTION

INTERNAL

DIR
DEP-T
AD-S

A&TS-PAT
Mr. L. D. Wofford, Jr.

PM-PR-M
A&TS-MS-H
A&TS-MS-IP (2)
A&TS-MS-IL (8)
A&TS-TU (6)

S&E-ASTN-DIR
Mr. K. Heimburg
Mr. J. E. Kingsbury
Mr. F. Kramer (50)

S&E-ASTN-X
Mr. K. Riggs

S&E-ASTR-DIR
Mr. M. Horton

S&E-ASTR-B
Mr. F. Cagle

S&A-ASTR-G
Mr. C. Mandel
Dr. G. Doane
Mr. P. Broussard
Mr. C. Jones

S&E-ASTR-S
Mr. F. Wojtalik

S&E-ASTR-SD
Mr. E. B. George

S&E-CSE-DIR
Dr. W. Haeussermann

S&E-CSE-L
Mr. J. Hamilton

S&E-P-DIR
Mr. H. Kroeger
Mr. F. Vreuls

S&E-P-LRV
Mr. W. Wagnon

S&E-DIR-R
Mr. H. Weidner

S&E-QUAL-DIR
Mr. J. Trott

PM-SAT-DIR
Mr. R. Smith
Mr. B. Montgomery

PM-SAT-A
Mr. J. Moody

PM-SAT-LRV
Mr. S. F. Morea
Mr. J. Sisson
Mr. J. Jones
Mr. A. Hughes
Mr. W. R. Perry

DISTRIBUTION (Concluded)

EXTERNAL

Manned Spacecraft Center
Houston, Texas 77058
Attn: Col. James A. McDivitt — PA
Mr. R. Battey — PD
Mr. G. Franklin — CF 131
Mr. D. Pendley — PA
Mr. O. Morris — PA
Maj. C. Duke, Jr. — CB
Mr. H. Scott — PD 5
Mr. W. Scott — FM 7
Maj. A. Aorden — CB
Col. D. Scott — CB
Lt. Col. J. Irwin — CB
Maj. J. Lousma — CB
Dr. R. Parker — CB
Mr. J. Cooper —FC 9

NASA Headquarters
Office of Manned Space Flight
Washington, D.C. 20546
Attn: Dr. Rocco Petrone — MA
Mr. W. Stoney, Jr. — MAE
Mr. B. Milwitzky — MAE
Mr. R. Diller — MAE

Scientific and Technical Information
Facility (25)
P.O. Box 33
College Park, Maryland 20740
Attn: NASA Representative (S-AK/RKT)